UNIVERSITY OF ALBERTA

SOME ASPECTS OF THE ECOLOGY OF ISLAND-NESTING WATERFOWL AT MIQUELON LAKE, ALBERTA

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Some Aspects of the Ecology of Island-Nesting Waterfowl at Miquelon Lake, Alberta", submitted by Leonard Wayne Dwernychuk in partial fulfilment of the requirements for the degree of Master of Science.

"In all the things of Nature there is something marvellous [*sic*]" Aristotle (384-322 B.C.), Parts of Animals (in Singer, 1959).

ABSTRACT

An ecological study of nesting waterfowl was conducted on two islands and a peninsula in Miquelon Lake, Alberta. In addition to observations of population parameters, aided through a study of nesting waterfowl, experimentation through habitat manipulation was conducted to test hypotheses concerning the roles of predation on, and habitat selection by, waterfowl.

The species studied included lesser scaup (*Aythya affinis*), gadwall (*Anas strepera*), mallard (*A. platyrhynchos*), pintail (*A. acuta*), white-winged scoter (*Melanitta deglandi*), and American widgeon (*Mareca americana*).

Evidence indicates that waterfowl concentrate on islands to nest in response to their insular position which excludes many mammalian predators. Distribution of vegetation on the islands affected the distribution and density of waterfowl nests. The presence of gulls neither attracted nor repelled waterfowl from nesting on the islands. The numbers of gulls, which influenced the development of vegetation, indirectly influenced the density of nesting waterfowl.

The number of nests of waterfowl declined from 130 in 1964 to 64 in 1967. The mean clutch sizes for individual species studied did not vary significantly between years nor were they different from those

reported in the literature. The onset of nesting for mallards and pintails was independent of temperature and precipitation during the early spring of each year.

The proportion of nests hatching between 1964 and 1967 increased significantly. Predation was the only major cause of egg losses during the investigation. Crows (*Corvus brachyrhynchos*), magpies (*Pica pica*), California gulls (*Larus californicus*), and ring-billed gulls (*L. delawarensis*) were responsible for egg losses on the islands. Mammalian predators, coyotes (*Canis latrans*) in particular, were also active on the peninsula. There was no correlation between the amount of overhead cover at waterfowl nests and susceptibility to predators.

Waterfowl broods were vulnerable to gull predation on first entering water. The survival of ducklings associated with large concentrations of gulls was very low.

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The assistance of the following persons during the course of the study was most valuable: my father, Mr. J. S. Dwernychuk for helping in the construction of vegetation plots used in the herbicide experiment in 1966; Messrs. L. Noël, G. Francis, and R. Gupta for applying herbicide on the islands in 1966; Mr. G. Glova

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1. INTRODUCTION

Waterfowl form one of North America's most important wildlife resources. In order to manage this resource wisely it is imperative that every effort be made to understand the ecology of this group of birds.

Since the 1950's, concern has increased over the decline in waterfowl populations on this continent as a result of habitat loss (Munro, 1965). Consequently, efforts have increased to effectively maintain and develop the remaining habitat. The significant role that islands play in waterfowl production has been recognized, and the introduction of man-made islands to natural breeding areas has been accepted as a feasible management scheme (Naylor, 1953; Hammond and Mann, 1956; Mikel'son and Lein'sh, 1964; Anderson, 1965).

The study which I undertook was an investigation of some of the factors influencing waterfowl production on natural islands in Miquelon Lake, Alberta. Both waterfowl and gulls nested in relatively high numbers on the islands.

Vermeer (1967), working with gulls on the islands of Miquelon Lake stated that during the summer of 1964 waterfowl nesting success was high but fledging success extremely low. He located 67 lesser scaup and 29 gadwall nests on the 2 main islands. Hatching success of these clutches was estimated at 90 per cent. However, he concluded that it was unlikely that any duckling from

these islands survived beyond its fourth day of life. Vermeer attributed this loss to heavy predation by California gulls.

Gulls have been recorded utilizing the eggs and young of waterfowl as a food source (Greenhalgh, 1952; Odin, 1957; Rienecker and Anderson, 1960; Choate, 1967; and others). Other investigations, however, have shown gull predation to be insignificant or nonexistent (Lewis, 1941; Gross, 1945; Behle and Goate, 1957; Hanson and Browning, 1959; Hilden, 1964). It is apparent that a contradictory situation exists with regard to the productivity of waterfowl associated with gulls. This situation prompted the initiation of a study to document the relationship at Miquelon Lake. If gulls were detrimental to waterfowl production, then the island habitat created an "ecological trap" for nesting waterfowl. Consequently, it was important to determine what factors were attracting waterfowl to the islands for nesting purposes. Specifically, I attempted to determine the impact of associated avian species and vegetation on waterfowl production on the islands of Miquelon Lake. I also endeavored to determine the role of gull colonies and vegetation in habitat selection on the island study areas.

Six waterfowl species were considered in this study. These were: lesser scaup, gadwall, mallard, pintail, white-winged scoter, and American widgeon.

These species of waterfowl and California and ring-billed gulls coinhabited the islands for nesting purposes.

2. DESCRIPTION OF THE STUDY AREA

Miquelon Lake is situated 30 miles south-east of Edmonton, Alberta (lat. 53° 32'N; long. 113° 32'W), at an altitude of 2518 feet. Kerekes (1965) reported that the dimensions of the lake were 3 miles by 2 miles in 1964, with an average depth of 9 feet. Total alkalinity was found to be 1383 ppm with a pH range of 9.3 to 9.5.

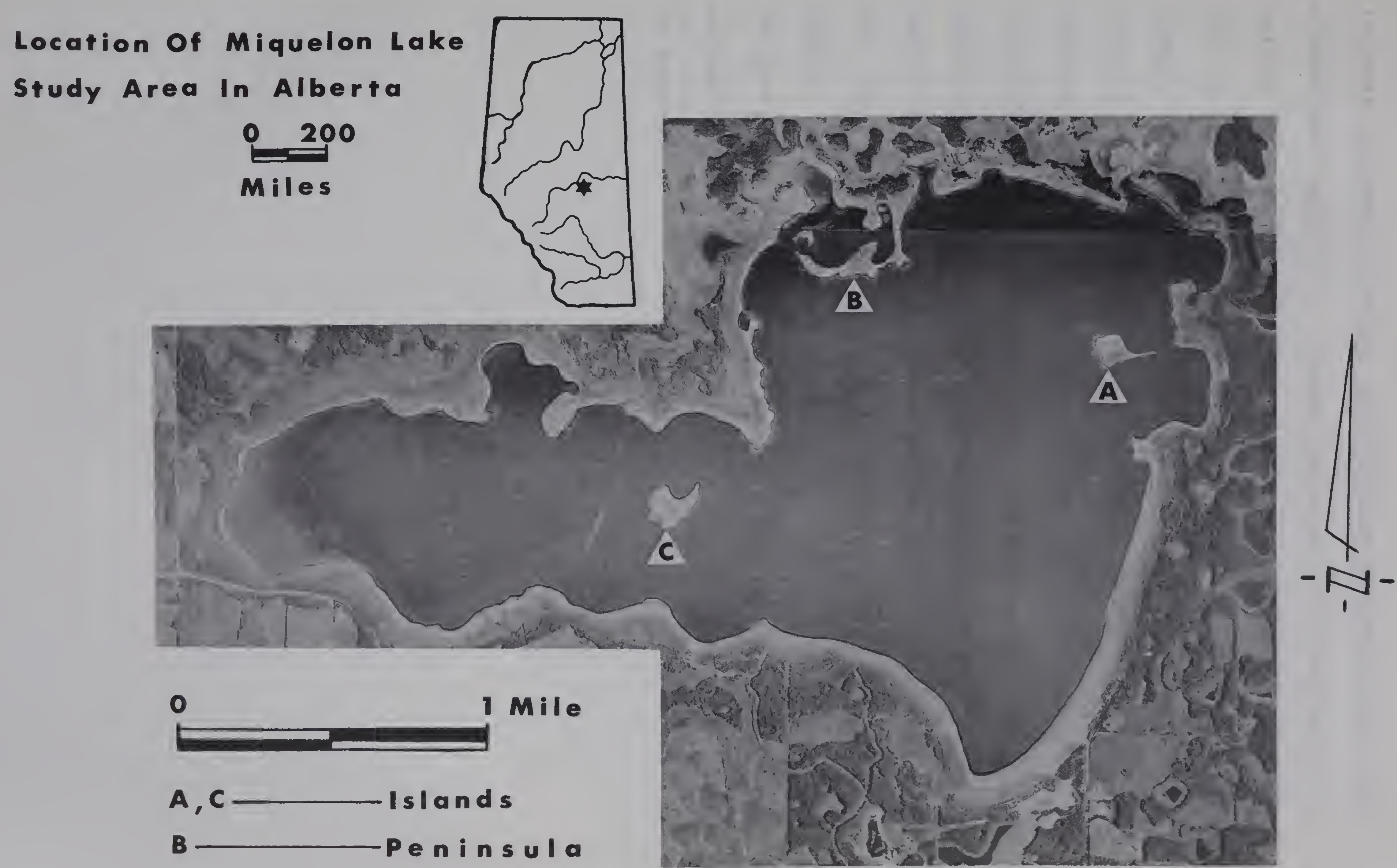
The shoreline supports very little emergent vegetation and is composed primarily of mud, sand, and an abundance of pebbles and boulders. Numerous ponds and marshes are near the lake (Fig. 1).

Two islands, A and C (Fig. 1), were the main sites of study, with the peninsula complex, B, observed to a lesser extent.

There has been a gradual increase in the areas of both islands because of a slow drop in water level. Island A was approximately 7.1, 7.4, and 8.2 acres, and island C 5.0, 5.1, and 5.5 acres for the years 1965, 1966, and 1967, respectively. The highest point above the lake's surface on both islands was approximately 6 feet.

Boundaries of floral communities were relatively well defined. A small number of trees and shrubs, including *Populus tremuloides*, *Salix* sp., *Cornus stolonifera*, *Ribes oxyacanthoides* and *Rosa woodsii* grew on island A. Island C had only a small group of *Populus tremuloides* and some *Ribes oxyacanthoides*. On both

Fig. 1. Miquelon Lake.


Location Of Miquelon Lake
Study Area In Alberta
0 200
Miles
A
B
C
0
1 Mile
A, C Islands
B Peninsula

islands *Glyceria striata* and *Hordeum jubatum* were the predominant grasses. *Suaeda depressa*, indicative of saline waters, grew on the muddy and sandy shores. The island interiors supported numerous herbs, the more common including *Urtica gracilis*, *Cirsium arvense*, *Scirpus americanus*, *Scirpus validus*, *Carex rostrata*, *Sonchus arvensis*, *Artemisia absinthium*, *Descurainea richardsonii*, *Chenopodium album*, *Axyris amaranthoides*, *Amaranthus retroflexus*, *Taraxacum officinale* and *Juncus balticus* (Vermeer, 1967). *Ruppia occidentalis* was the only aquatic plant growing on the lake bottom (Kerekes, 1965). Vermeer (1967) gives a more detailed account of terrain, lake history, less common herbs, and the vertebrate fauna associated with the islands and lake in general.

3. METHODS

The study at Miquelon Lake was undertaken during the summers of 1965, 1966, and 1967. During the first two seasons observations were carried out from the second and third week in May, respectively, to the middle of August. In 1967 the study began in early May, terminating the middle of August. I lived in a cabin constructed on island A for the duration of the study.

In a study of crow-waterfowl relationships in Alberta and Saskatchewan, Kalmbach (1937, p. 7) stated "it cannot be emphasized too strongly...that careless intrusion of human beings into duck-nesting areas creates a hazard of utmost importance...". Earl (1950), Keith (1961), and Choate (1967) have concluded that human disturbance on their study areas had the effect of increasing predation and desertion in waterfowl nesting populations. Sowls (1955) similarly recognized this danger in the nest-history approach to waterfowl research.

Hammond and Forward (1956) have experimented with various observational techniques in an attempt to determine to what extent these may influence predation. Factors such as hens defecating on eggs when flushed, nest markers, on occasion trails of the observer, and at times human activity were found to increase nest losses. The only way observers can alleviate the problems caused by human intrusion is to minimize the effect of this unnatural variable. These warnings were recognized from

the onset of this study, and efforts were made to reduce, as much as possible, the effect of my presence on the island populations.

In order to record events at specific nests, markers were placed 25-30 feet from them. Vegetation surrounding a nest was disturbed as little as possible, and the formation of trails to nest sites was avoided. Nests found by the author with eggs visible were covered with down or associated plant material from the periphery of the nest. Visits to nests were restricted to once every 2-3 days and observations were recorded as quickly as possible. The avoidance of rapid movement and excessive noise, vocal or otherwise, both at the camp site and in the field, was strictly adhered to. Any collecting of data that required venturing into the field at other than the regular interval time was done as rapidly as possible, and nest searching and inspection was postponed if crows or magpies were near or on the islands.

When a nest was discovered, the species of waterfowl involved was recorded. A number was allotted to the nest location and the location recorded. Distance to water, to the site of nearest nesting duck of any species, and to the site of nearest nesting gull of either species, was recorded. The date when the nest was located and the clutch size at that time were noted.

In 1966 and 1967 nests were given cover ratings, that is, they were rated according to their visibility

from above. Ratings were 0, 1, 2, 3, which corresponded to poor, fair, good and excellent overhead cover, respectively. "Poor" indicated a lack of overhead cover thus rendering a nest completely visible, and "excellent" described a nest which was invisible. Variations between these two extremes were described by ratings of 1 and 2. The species and condition of the vegetation in which nests were located was noted.

The status of all nests was followed throughout the nesting season and their fates recorded. When hens were well on in incubation, approximately 21-22 days or later, they were trapped with a bow-net trap (Salyer, 1962). An aluminium Fish and Wildlife Service band was placed on the right leg, and quick-drying spray paint was applied to one or both fore-wings and allowed to dry thoroughly before the bird was released. A different color combination was assigned to each captured bird, thus enabling recognition of individual hens and broods on the lake after the hatch. Colors used were red, yellow, blue, green, and gold. Markings were discernible for a period of about 4 weeks.

An attempt was made to determine experimentally the relationship of vegetative cover to nest predation, and to compare this with the actual predation on waterfowl nests. Ninety dozen chicken eggs were obtained and used in an experiment involving dummy nests on island A and C, and peninsula B. The experiment extended from June 1

to July 26, 1967. On islands A and C, 16 nests per island were distributed, four in each cover value (0 to 3 inclusive), each containing 6 white eggs. On B, a total of 8 nests were constructed, two in each cover class. Dummy nests were hollowed out 1 1/2-2 inches, lined with grass, and the eggs covered with bits of the associated vegetation, simulating an actual duck nest. These nests were marked by a small block of wood approximately 15 feet away, with an arrow pointing in the direction of the nest site. Some nests were so well concealed that I often experienced difficulty in relocating them. These nests were checked at the same interval as waterfowl nests (2-3 days). A total of 40 dummy nests were maintained throughout the experiment. If, for example, eggs in a nest with a cover value of 2 were preyed upon, the nest site was cleaned, and a new dummy nest under comparable cover was established in another location on the island. Efforts were made to space these nests. The experiment was terminated July 6 on the peninsula B as cattle were trampling the majority of nests.

On both islands A and C, 3-4 number "0" steel traps were set at some of the dummy nest sites. Traps were padded to avoid injury to predators that might be captured. This trapping was done in an attempt to determine the extent of nest pilfering by suspected predators.

Throughout the study period, 1965 to 1967 inclusive, I made observations on the interaction of gulls and crows, when the latter frequented island C. I also observed dummy nests to verify any predatory activities by gulls on eggs. When possible, I attempted to ascertain the extent of predation by gulls on ducklings.

There has been a gradual decrease in nesting gull populations on island A from 1964 to 1966, with a fluctuation in numbers on island C. In 1967 gulls were prevented from nesting on island A. This permitted the collection of data on waterfowl nesting when gull populations were relatively high in 1965, at a lower level in 1966, and not present in 1967. The data obtained could then be compared to waterfowl data collected incidentally by Vermeer in 1964.

Vegetation associations on islands A anc C were mapped for the years 1965, 1966, and 1967 (Figs 2 and 3). In 1966 each island was divided into two areas for the purpose of herbicide application. The dividing lines are omitted from Figs. 2 and 3 in 1966 because spraying was done following the period of nest initiation by waterfowl and therefore had no effect on nesting during that year. As herbicide application was undertaken throughout the summer in 1967 the density of vegetation in sprayed zones of islands A and C is less than that observed in the untreated plots.

In 1966 and 1967, transects were laid out on both

Fig. 2. Distribution of plant communities on island A from 1965 through 1967.

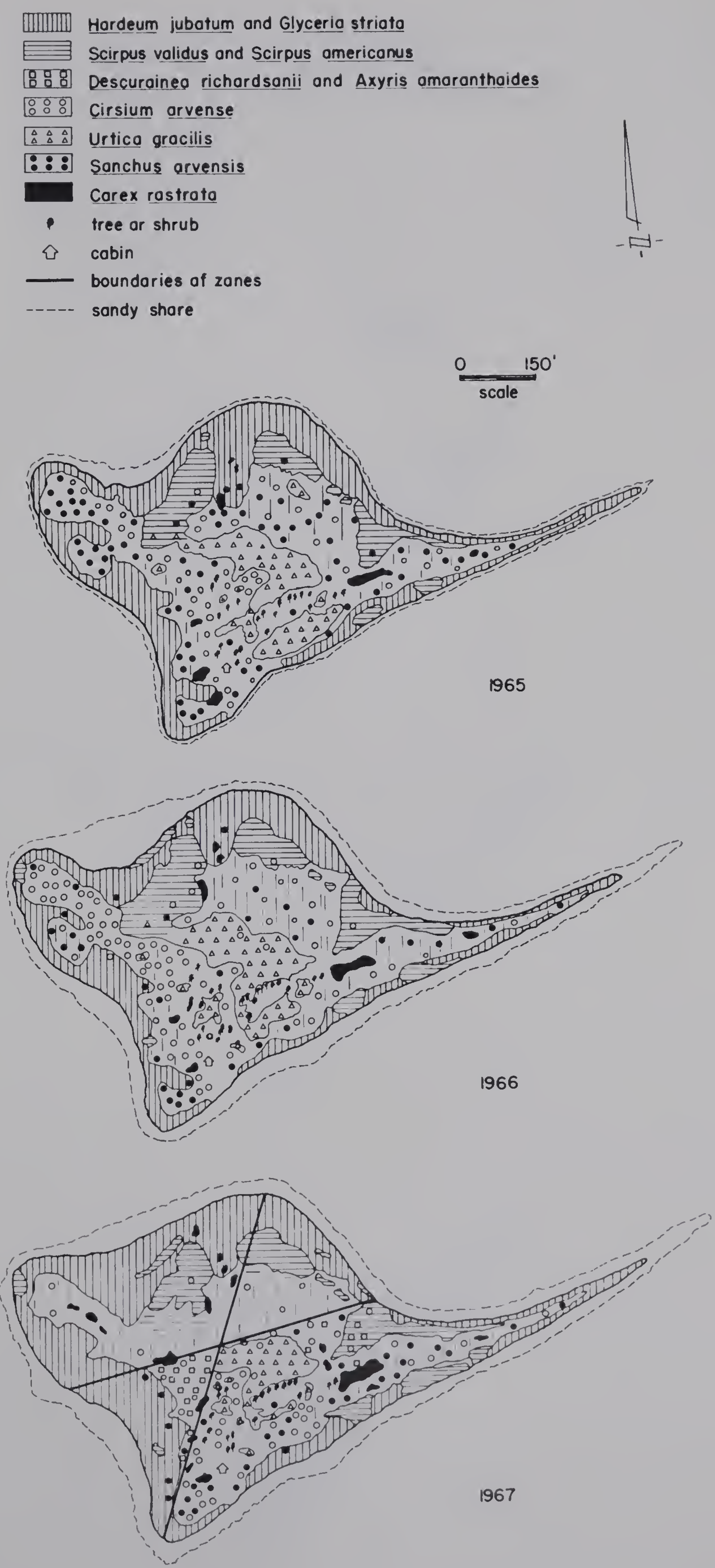
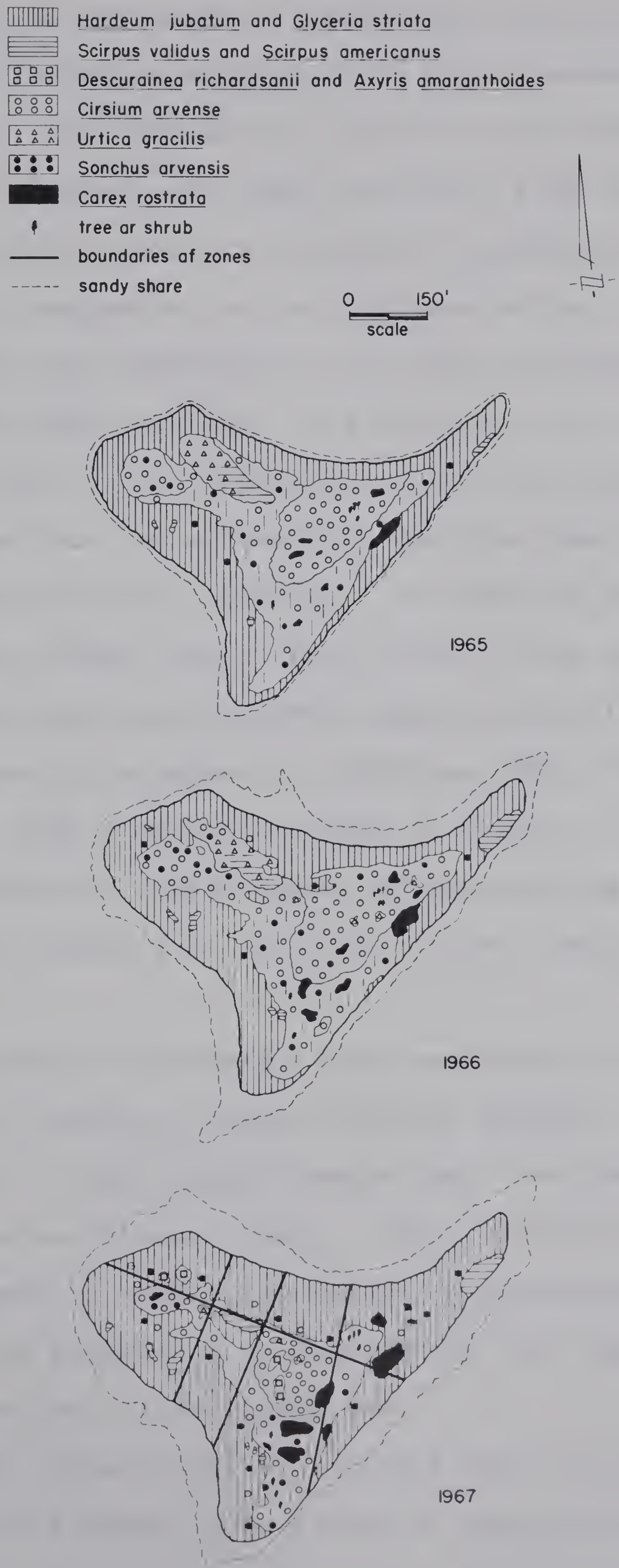

Hardeum jubatum and Glyceria striata
Scirpus validus and Scirpus americanus
Descurainea richardsanii and Axyris amaranthaides
Cirsium arvense
Urtica gracilis
Sanchus arvensis
Carex rastrata
tree ar shrub
cabin
boundaries af zanes
sandy share
0 150'
scale
1965
1966
1967

Fig. 3. Distribution of plant communities on island C from 1965 through 1967.


Hardeum jubatum and Glyceria striata
Scirpus validus and Scirpus americanus
Descurainea richardsanii and Axyris amaranthoides
Cirsium arvense
Urtica gracilis
Sonchus arvensis
Carex rostrata
tree ar shrub
boundaries af zones
sandy share
0
150'
scale
1965
1966
1967

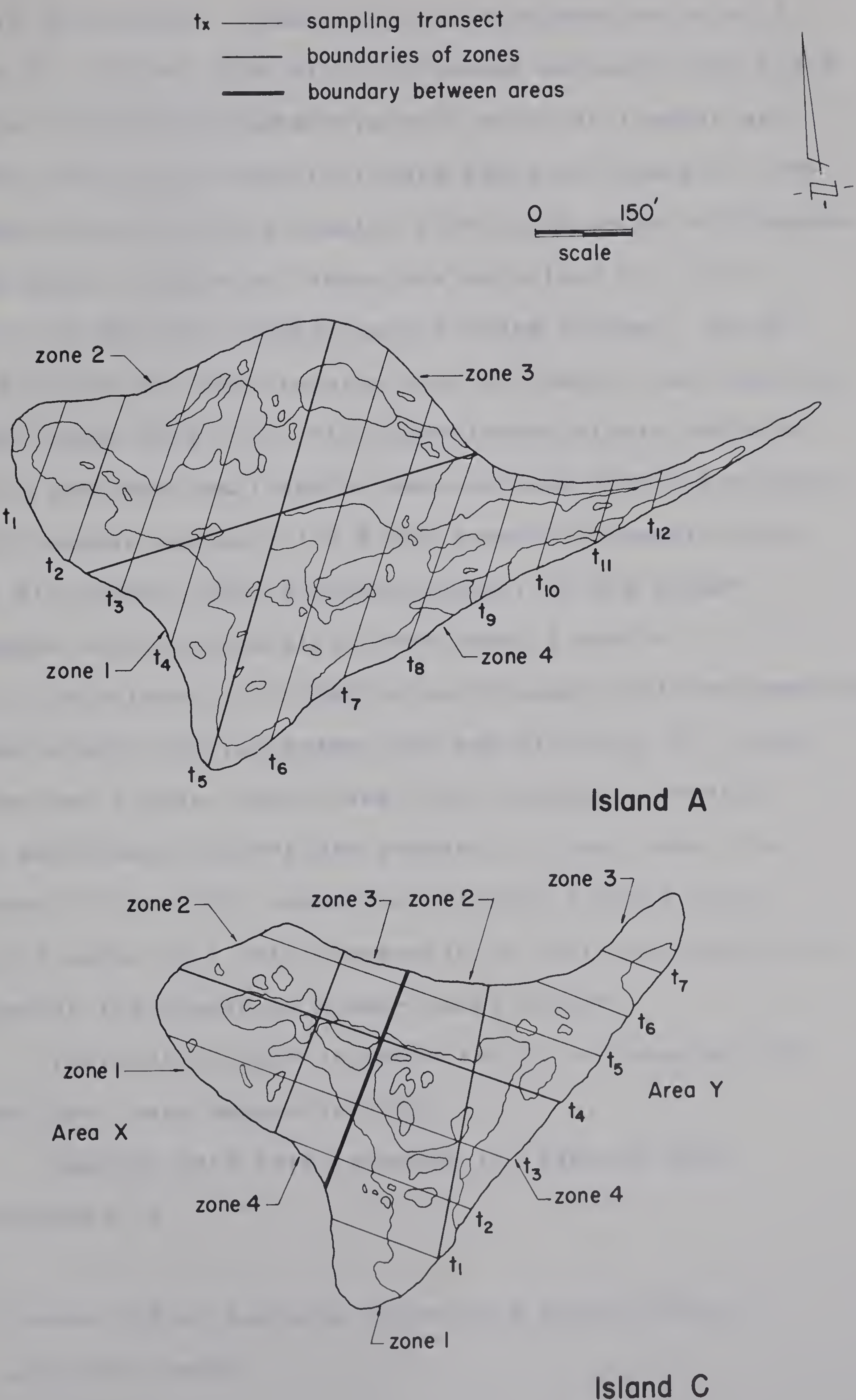
these islands for purposes of vegetation analyses (Fig. 4). Twenty-five samples were taken along each transect at set intervals. At transect 5, island A, and transect 4, island C, samples were taken on either side of this line, since these transects represent a separation of experimental treatments, to be discussed below. Vegetative analyses were undertaken five times throughout the summer during 1966 and 1967. The first analysis was run in late May on dry vegetation of the previous year. Only dry vegetation more than 6 inches high was considered in the analyses, because I believe any dry growth less than this height was of no or very little cover value. The remaining four analyses were taken at specific intervals from June 15 to August 14, 1966 and 1967. New growth was excluded from a sample if under 3 inches in height.

The Daubenmire (1959) method of determining canopy coverage and frequency of particular plant species was used.

Plant genera considered in the analyses were *Hordeum* and *Glyceria*, *Scirpus*, *Cirsium*, *Urtica*, *Sonchus*, *Carex*, and *Artemisia*. Other plants deemed less important were lumped in a miscellaneous class. These analyses were undertaken both to reveal the general growth pattern throughout the season and to demonstrate the impact of herbicides on the island vegetation.

In 1966, the portions of island A west of transect 5 and north of transect 4 on island C, were divided into

Fig. 4. Islands A and C in 1967 showing the positions of plant communities, sampling transects used in 1966 and 1967, and the boundaries delineating zones and areas.



t_x sampling transect
boundaries of zones
boundary between areas
0 150′
scale
zone 2
zone 3
zone 1
zone 4
t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12}
Island A
zone 2
zone 3
zone 2
zone 3
zone 1
Area X
zone 4
Area Y
zone 4
zone 1
t_1 t_2 t_3 t_4 t_5 t_6 t_7
Island C

1/10 acre plots. These plots were sprayed on July 13 and 14. Tordon 22K* at 1 1/2 ounces per acre, and 2,4-D ester (2,4-dichlorophenoxyacetic acid) at 1 pound per acre, were restricted to single plots on island A. The remaining plots were treated with 2,4-D ester at 2 pounds per acre, as were all the plots on island C.

In 1967 the islands were divided further. On A, a division was made running east and west, thus creating four zones (Fig. 4). All broad-leaved plants north of this east-west delineation were sprayed with 2,4-D ester at 2 pounds per acre 1-2 times a week from early June to mid August, thus eliminating most of the broad-leaved nesting vegetation from zones 3 and 4.

On island C, in 1967, a north-south division separated the island into two areas, "X" and "Y" (Fig. 4). Each area was further subdivided into 4 separate zones by an additional north-south boundary in each area. In areas "X" and "Y", zones 3 and 4 were treated with 2,4-D ester at a rate comparable to that on island A to prevent the growth of broad-leaved plants.

Contours of both island A and C, at intervals of one foot, were mapped in 1965.

Weather data were recorded in 1966 and 1967 (Appendix 1).

* Tordon 22K or picloram (4-amino-3,5,6-trichloropicolinic acid)

An analysis of variance was applied to data on the distance of waterfowl nests to water on islands A and C. Correlation coefficients were calculated for the relationship of the number of nests existing at a given time of the nesting season and the number destroyed by predators. In order to ascertain whether the observed distribution of waterfowl nests on the islands in 1965, 1966, and 1967 departed significantly from a random distribution, the nearest neighbor analysis as outlined by Clark and Evans (1954), was used. Derivation of the theoretical random curve was by a formula acquired from Dr. J. M. Cullen by Vermeer (1967). The method is presented in more detail in Appendix 2. In all statistical tests the null hypothesis was rejected if the probability level was greater than 0.05.

4. RESULTS AND DISCUSSION

4.1 Nesting Populations

The island habitat offers breeding waterfowl a number of desirable features that may assure a relatively high rate of nesting success. Keith (1961) found that the overall nesting success was 76 per cent on islands and 35 per cent on other parts of his study area. Kalmbach (1937), Craighead and Craighead (1949), and Anderson (1965) reported 75, 95, and 82 per cent, respectively, of the total nesting waterfowl population in their individual study areas, were located on islands. Similarly, in a study of nesting waterfowl in the Saskatchewan River delta, Townsend (1966) stated that island habitats comprised only 30 per cent of the total area searched; however, 43 per cent of the waterfowl nests found were on these islands. The nesting success on the island areas was 53 per cent, and on the mainland 47 per cent. It appears that islands possess some distinct adaptive advantage which "funnels" in a high proportion of the population of nesting waterfowl. The islands of Miquelon Lake are probably no exception.

All waterfowl species studied at Miquelon Lake are known to utilize islands for nesting purposes, some to a greater extent than others. All species were already present on the study area when I arrived each spring.

Table 1 summarizes the numbers of waterfowl nesting

Table 1. Numbers of waterfowl nests on islands A and C at Miquelon Lake from 1964 through 1967.

Species	Location								Total							
	Island A				Island C											
	1964*	1965	1966	1967	1964*	1965	1966	1967	1964*		1965		1966		1967	
									No.	%	No.	%	No.	%	No.	%
lesser scaup	41	42	20	10	26	28	21	14	67	52	70	59	41	53	24	37
gadwall	26	15	16	11	3	10	2	6	29	22	25	21	18	24	17	27
mallard	9	3	2	5	3	3	3	2	12	9	6	5	5	7	7	11
pintail	2	1	2	3	4	6	1	5	6	5	7	6	3	4	8	12
white-winged scoter	9	1	6	3	2	7	1	4	11	8	8	7	7	9	7	11
American widgeon	3	1	1	1	2	1	1	0	5	4	2	2	2	3	1	2
redhead	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0
Total	90	63	47	33	40	55	30	31	130	100	118	100	77	100	64	100
% total nesting population in given year	69	53	61	52	31	47	39	48	100		100		100		100	

*K. Vermeer--pers. comm.

on islands A and C for four consecutive seasons. Lesser scaup and gadwall were the most abundant species, while pintails, white-winged scoters, and mallards nested in considerably lower numbers. American widgeons and redheads were only incidental.

I believe, after three summer's observation of populations on Miquelon Lake, that the predominant waterfowl species is lesser scaup. Therefore, the preponderance of this species nesting on the islands is to be expected. Lesser scaup seem to display a preference for small lakes, ponds, marshes and streams (Bent, 1923). Miquelon Lake falls into the category of "small lakes", hence offering an appropriate habitat in this respect.

Waterfowl of the genus *Anas* seem to prefer shallow bodies of water with silt or mud bottoms (Hilden, 1964). Ponds and sloughs exhibiting these basic characteristics would tend to be most attractive to these species if an abundance of aquatic and emergent vegetation were available, providing food and shelter. The rich growths of these aquatic and emergent plants in any body of water would be reflected in a high organic matter content in bottom sediments. Kerekes (1964) found Miquelon Lake to have an average, bottom, organic matter content of 14 per cent. This was considerably lower than he reported for any of the four other lakes studied. The closest value was 30.6 per cent for Ministik Lake, and the highest value was 47 per cent for Antler Lake. The relatively high salinity of

Miquelon Lake probably limits the number of aquatic plant species (Rawson and Moore, 1944). The limited amount of emergent vegetation is confined to a few sheltered bays. Thus, the relatively low numbers of nesting mallards and pintails on Miquelon Lake is probably a reflection of the low abundance of emergent and aquatic vegetation. The lake's deep water and the fact that mallards and pintails display a tendency to nest at considerable distances from water (Bent, 1923), are other possible factors influencing their apparent avoidance of the islands.

Gadwalls were the second most abundant species. The presence of this species in such high numbers seems to contradict the generalization proposed by Hilden (1964). A lush growth of herbaceous plants was available to prospective nesting birds on the islands. Gadwalls are noted for their extensive use of this form of vegetation for nesting purposes (Williams and Marshall, 1938; Hammond and Mann, 1956; Keith, 1961; Duebbert, 1966). This could possibly be the prime attracting feature of the islands, outweighing the negative attributes of the environment that may make the area unsuitable for mallards and pintails.

American widgeons were observed in extremely low numbers throughout the lake during the three seasons, therefore, it is not surprising that their nesting populations would be correspondingly low. White-winged scoters were always relatively numerous on the lake;

however, there were few nests of this species on the islands. This lack of nests on the island study areas I attribute to their selection of nesting sites elsewhere, possibly adjacent to the small marsh-like ponds near the lake. Many more white-winged scoter broods were observed on the lake than could have been produced on the islands, consequently, they must have selected alternate nesting sites.

Only one redhead (*Aythya americana*) nest was located during the study. This was on island C in 1966.

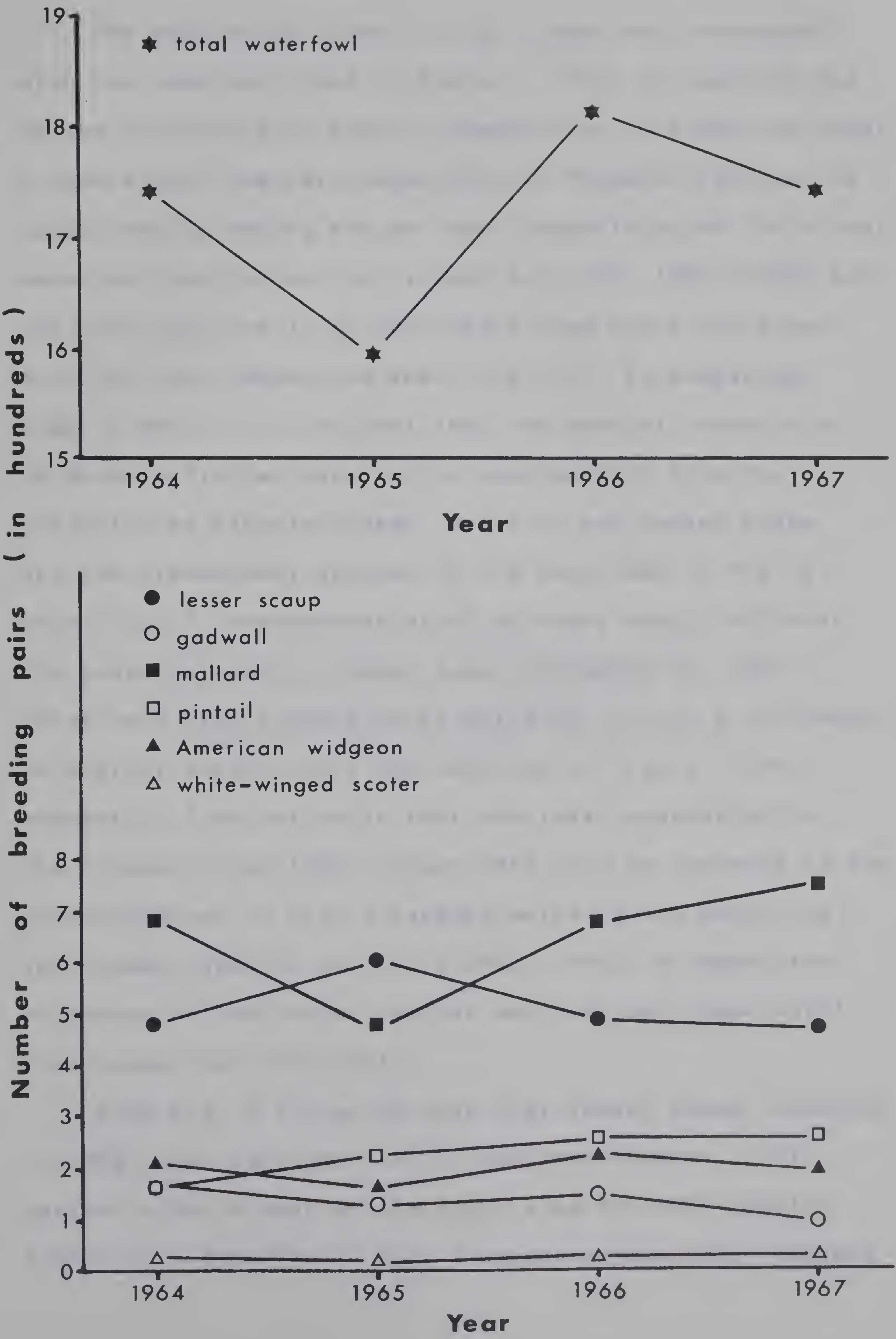
Because of the relatively small size of the islands a total count of nesting waterfowl was believed achieved.

The total waterfowl population on islands A and C dropped from 130 nests in 1964, to 64 in 1967 (Table 1). A number of explanations for this decline can be proposed. One is that it may reflect a general decline in waterfowl populations throughout central Alberta.

Ducks Unlimited carries out breeding pair censuses in the Tofield-Ministik Lake area, just north of Miquelon Lake. This is done usually during the third or fourth week in May each year. The census transects covered an area of 88 square miles and included between 8.5 and 14.5 water areas per square mile for the period 1964 to 1967. The popualtion trend from Ducks Unlimited data over this period for the six species of waterfowl involved in my study is shown in Fig. 5. A breakdown of the overall trend into individual species is seen in Fig. 6.

Fig. 5. The number of breeding pairs of waterfowl in the Tofield-Ministik Lake area from 1964 through 1967, courtesy Ducks Unlimited, Edmonton.

Fig. 6. The number of breeding pairs of individual species of waterfowl in the Tofield-Ministik Lake area.


total waterfowl
19
18
17
16
15
1964
1965
1966
1967
Year
Number of breeding pairs (in hundreds)
lesser scaup
gadwall
mallard
pintail
American widgeon
white-winged scoter
8
7
6
5
4
3
2
1
0
1964
1965
1966
1967
Year

The population trend in Fig. 5 does not correspond with the observed trend in Table 1. This is possibly due to the difference in species composition in these two areas. A theoretical species composition at Miquelon Lake can be calculated by taking the per cent composition of individual waterfowl species on the islands for 1964, 1965, 1966, and 1967 and applying it to the totals from Ducks Unlimited data for each respective year (Fig. 7). By comparing Figs. 6 and 7 it is evident that the species composition in Ducks Unlimited data varies considerably from the situation at Miquelon Lake. Mallards and lesser scaup are the predominant species in the data seen in Fig. 6, while Fig. 7, representative of my study area, indicates the preponderance of lesser scaup and gadwalls. The relatively high proportion of mallards in Fig. 6 influences to a great extent the trend observed in Fig. 5. Consequently, I do not think that the total population on the islands, from 1964 through 1967, can be compared to the trend observed in Fig. 5 because mallards are among the less common species on the islands. Thus, a comparison of trends of individual species would be more meaningful than comparisons of totals.

From Fig. 6 it can be seen that lesser scaup increased in 1965, then declined for two successive years. This pattern also is seen on the study area for this species (Table 1). Gadwalls in Fig. 6 appear to decline, increase

Fig. 7. Theoretical species composition, based on Ducks Unlimited data, of waterfowl nesting at Miquelon Lake from 1964 through 1967.

slightly, then decline again. Gadwalls on the study area undergo a general decline to 1966 then stabilize. White-winged scoters on the islands follow the trend in Fig. 6, but pintails, mallards, and American widgeons do not. However, because of the low numbers of the latter four species, valid trend comparisons are probably not possible.

Lesser scaup, being the most abundant species on the islands, are primarily responsible for the population trend on the study area as a whole (Table 1). Although their numbers correspond to the general pattern seen in Fig. 6, the relative proportions of the decline on the study area as compared to census data, differ noticeably. Marked declines in numbers of nests are observed on the islands after 1965. The declines in Fig. 6 are insufficient to account for the substantial loss of lesser scaup from the study area. Therefore, the population decline (Fig. 6) is only a partial explanation for the decrease in island populations, and must have been supplemented by other factors. A closer examination of the numbers of nesting waterfowl on islands A and C may clarify population declines observed from year to year.

Island A supported a higher number of waterfowl nests over the 4-year period than island C, an average of 59 per cent of the total nesting population on islands A and C. Island A, however, was larger than C by an average of 31 per cent, thus providing more potential nesting area. This may explain the greater number of

nests on island A. However, another possibility is the fact that the numbers of gulls on island A were not comparable to those on C. From 1964 to 1967 the numbers of gulls on island A declined as follows: approximately 1600, 300, 60, and 0 individuals, respectively, while those on C fluctuated from 3000, 900, 2000, and 2000 individuals for the same period of time. On island C, where considerably higher gull populations were present each year, there was a decreased amount of nesting cover, which may be one factor influencing the lower numbers of waterfowl nests found here.

Table 2 depicts the numbers of waterfowl nests on islands A and C and their relative rates of change from 1964 to 1967. Island A displays a steady decline in nest numbers during the study, while populations on C alternately increase and decrease. The fact that similar declines were not observed on both islands may suggest that factors other than general population trends are influencing population levels on individual islands. Human interference and variations in availability of nesting cover are two possibilities.

On both islands A and C, lesser scaup generally follow the trend observed by Ducks Unlimited (Fig. 6). In 1966 and 1967, island A had a 52 per cent and a 50 per cent decline in lesser scaup numbers, respectively, from the previous year; however, on C a 25 per cent and a 33 per cent decline was observed for these same years. This implies

Table 2. Changes in the numbers of waterfowl nests on islands A and C from 1964 through 1967. (+ = increase; - = decrease)

Year	Number of nests			% change from previous year		
	Islands		Total	Islands		Total
	A	C		A	C	
1964	90	40	130	-	-	-
1965	63	55	118	-30	+38	- 9
1966	47	30	77	-25	-46	-35
1967	33	31	64	-30	+ 3	-17

that since the reduction in numbers of lesser scaup nests varies so markedly between islands A and C, some factor must have prompted the greater decline on island A. Hilden (1965) found that in the marine archipelago along the Finnish coast, gulls, terns and waterfowl were less numerous on islets inhabited by man than on uninhabited ones. Island A was inhabited during the summers from 1964 through 1967. This, therefore, may have caused the continuous decline in the numbers of nesting waterfowl on this island. It is possible that older females, long associated with island A were not as greatly affected by my presence as younger birds. Perhaps these older individuals comprised the majority of each year's population. The younger birds, nesting for the first time, may have avoided this island and nested elsewhere. It is also conceivable that the declines that may have been induced by my presence were further magnified on island A through mortality in this older-aged group.

I do not think a decrease in nesting cover on island A, through the application of herbicides in 1966 and 1967, contributed significantly to the reduction in the total numbers of waterfowl nests there in 1967. The amount of cover that was available to nesting birds in the untreated zones was sufficient, judging from previous years, to accommodate more nests than were actually initiated. Therefore, the human factor was probably the more significant cause of the decline in numbers of waterfowl nests.

By comparing the total nesting population on island C with that of A, a difference in yearly trends is evident (Table 1). Island A populations decreased throughout, while those on C fluctuated. These fluctuations from year to year may be the result of gull colonies reducing vegetational cover, the movement of some nesting waterfowl from island A to C, or newly recruited hens selecting island C in favor of A.

There has been a fluctuation in the number of gulls on island C from 1964 to 1967.

The high gull population on island C in 1964, approximately 3000 individuals, I suspect, resulted in a substantial decrease in dense nesting cover for waterfowl. As I have no data on the condition of nesting cover for 1964, I can only speculate on the effect gulls had on vegetation, based on my observations in 1966 to be discussed below. With a limited amount of dense cover, those waterfowl species favoring this form of nesting cover would be affected most. Gadwalls, which prefer dense vegetation, were relatively high in numbers on island A as compared to C (Table 1). Dense nesting cover was probably more available on the larger island A where gull populations were lower. This would account for the variation in numbers of this species on islands A and C in 1964.

In 1965 gull populations on island C dropped to 900. At the same time the numbers of waterfowl nests on island A dropped by 30 per cent, but rose by 38 per cent on island

C (Table 2). This increase on C may be partially due to the slight increase in lesser scaup on the island, reflecting the increase of this species on the area in general (Fig. 6). However the more significant factor responsible for the increase may be related to the decrease in gull populations having a lesser effect on nesting vegetation utilized by waterfowl. It is also possible that the 38 per cent increase in numbers of nests on island C was facilitated, to a great extent, by the 30 per cent decrease in numbers on island A. Hens new to the area may also have selected island C in preference to A because of the lack of human presence. The former explanation implies a shift of birds from island A to C. This shift may very well have occurred. For instance, the gadwall trend in Fig. 6 appears to be followed to some degree by the gadwalls nesting on island A, but not by those on C. If the gadwall population on island C had followed the pattern observed on A, at least to some extent, the overall trend on the islands for gadwalls would have been similar to data in Fig. 6, as was the case for lesser scaup. However, the marked increase in numbers on island C in 1965 is contradictory to population data (Fig. 6), and may be the result of gadwalls moving from island A to C. If this shift did occur, it would have masked any decline that may have been observed if these island A gadwalls, in 1965, had moved from the lake area altogether.

In 1966 the gull population on island C increased

to approximately 2000 individuals. The population of nesting waterfowl on island C decreased by 46 per cent from 1965 (Table 2). This decrease can possibly be attributed to increased gull activity affecting waterfowl nesting cover, and to a lesser extent, the trend of lesser scaup populations in the area (Fig. 6). In some areas on island C in 1965, *Cirsium* grew to over 5 feet in height. In 1966, however, not one plant managed to emerge in these same areas. This I attribute to the trampling of gulls. In certain areas of the island, dry vegetation and gull feces were matted into an apparently impenetrable substrate. A reduced vegetational cover was the result, causing the number of waterfowl nests on island C in 1966 to similarily decline.

There was a slight increase in the number of nests on island C in 1967 (Table 2), when gull populations were comparable to those in 1966, and cover was further reduced by herbicide application to parts of the island. This increase may represent a continued movement of birds from island A to C (eg. gadwalls; Table 1), or possibly the selection of island C over A by recruiting waterfowl hens.

Peninsula B supported only an average of 5 per cent of the nesting population for 1965, 1966, and 1967 combined. This extremely low average, as compared to 53 per cent for island A and 43 per cent for island C, can be explained by the very sparse vegetational cover which

B afforded. The meager cover on this area was the result of grazing and trampling by cattle throughout the summer of each year. Thin patches of *Scirpus* and *Hordeum*, offering practically no cover, were the only possible nesting cover that was available to waterfowl. In addition to this, being associated with the mainland permitted the easy access of mammalian predators. This could have also discouraged waterfowl from nesting on this area.

Probably a complex of factors was involved in determining the numbers of waterfowl present on the study areas at Miquelon Lake. Factors that may have interacted and exerted some effect on waterfowl populations are as follows: presence of man, availability of nesting cover, presence of gulls, waterfowl population trends for the lake area, variations in mortality rates of older-aged female ducks, and insular position of nesting sites. The significance of each factor may depend on the individual study area, island A or C, or the B complex. For example, lack of suitable nesting vegetation on the B complex probably resulted in the low number of waterfowl nests on this area throughout the study. This factor could also be coupled with the fact that the B complex was subject to the activities of mammalian predators.

The consistently higher number of waterfowl nests on island A as compared to C, possibly can be attributed to the increased availability of nesting cover on island A through its larger size and lower gull populations.

However, the continuous decline in numbers of nests of waterfowl on island A may reflect a human presence on this island. The decline of gadwalls and lesser scaup over the lake area in general and mortality in the older-aged female duck population are other possible factors influencing the decline.

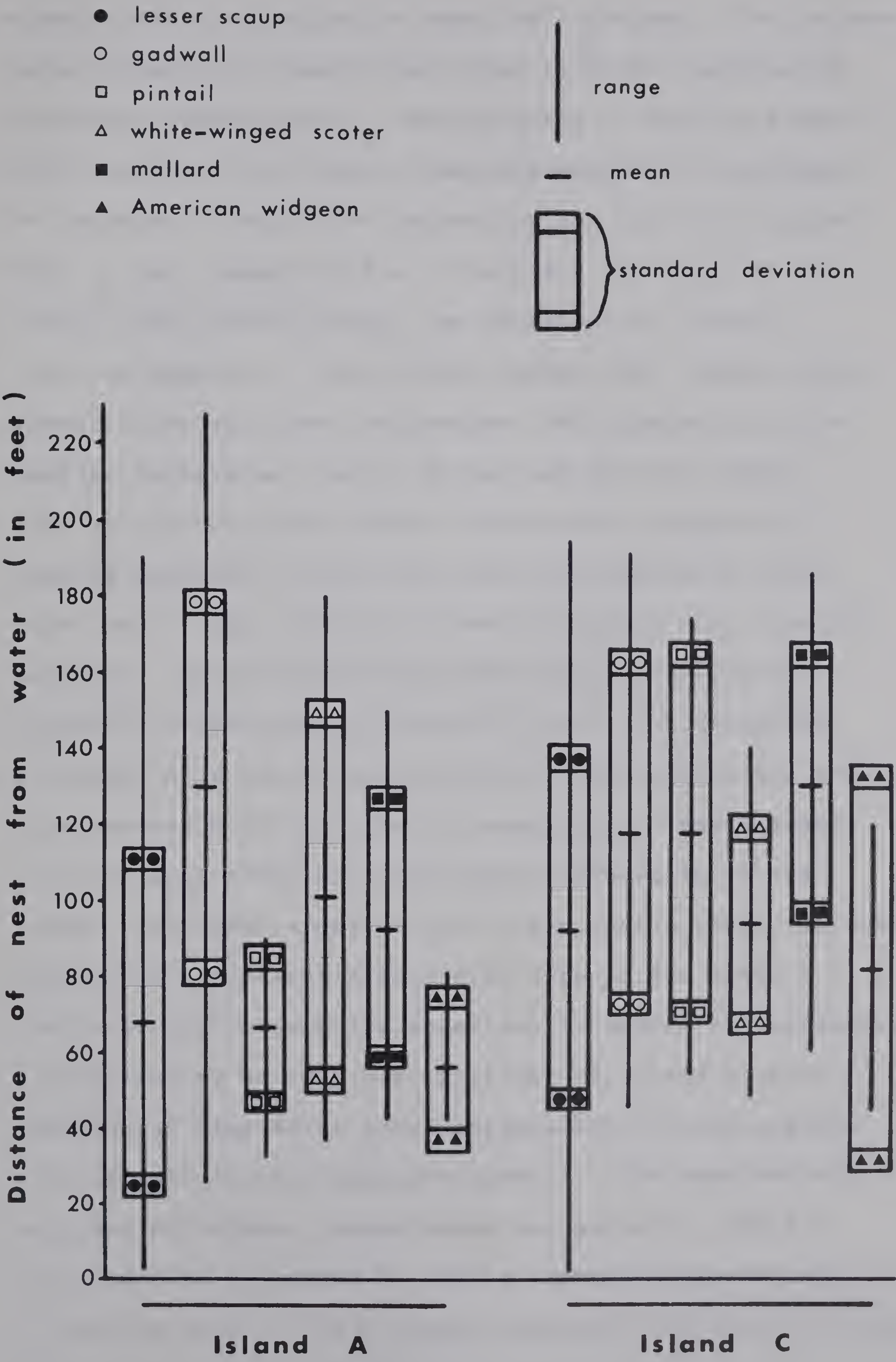
The most significant factors contributing to the fluctuation in waterfowl populations on island C appear to be changes in the availability of nesting cover, and possibly the effect of human disturbance on island A causing nesting waterfowl to move to island C.

4.2 Distances of Nests From Water

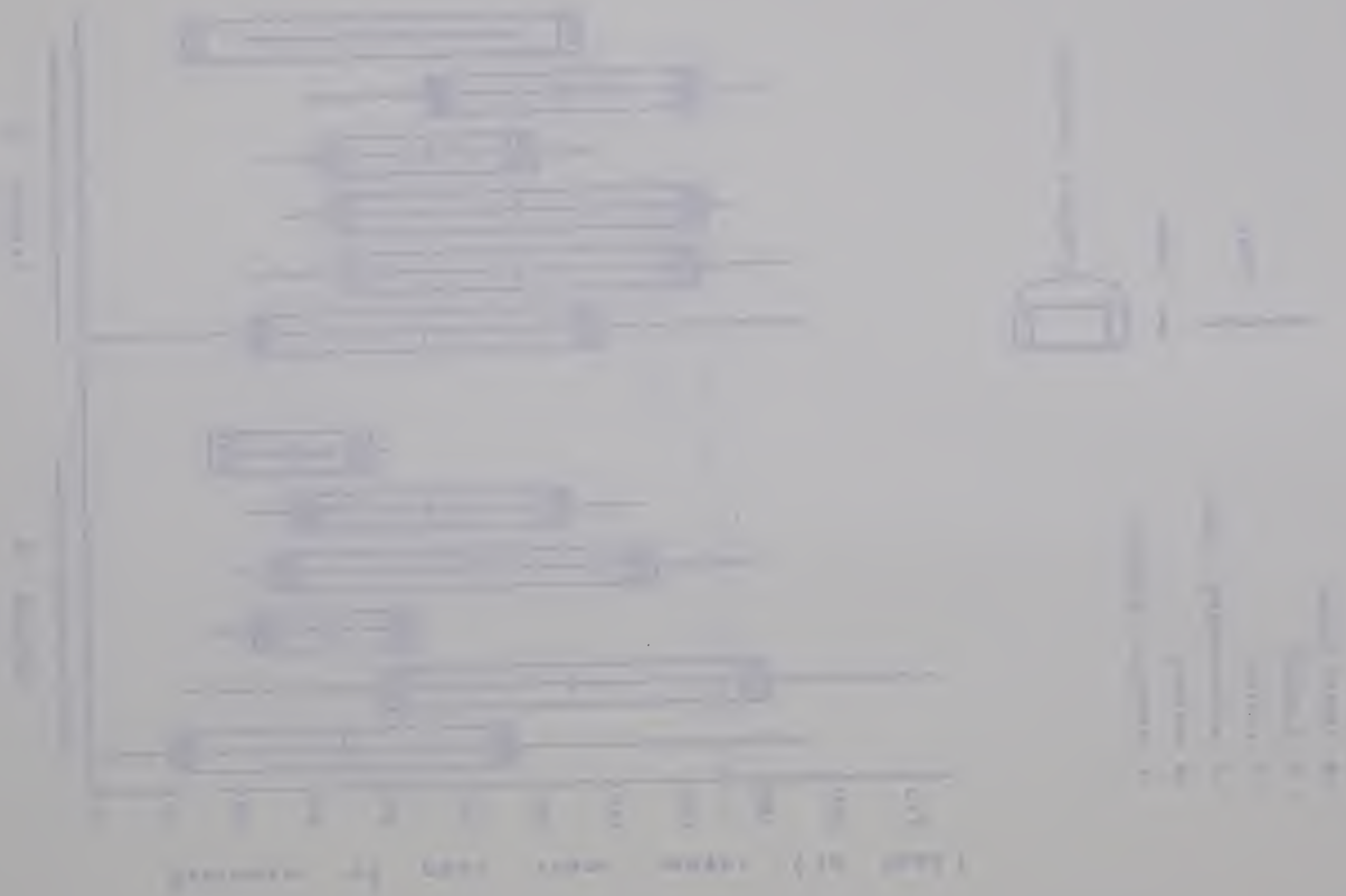
The distances of waterfowl nests from water on islands A and C were measured each season. This was undertaken in an attempt to determine whether certain species of waterfowl selected nesting sites in relation to the distance from water. The distances were averaged for each species during the years 1965 to 1967. The results are presented in Fig. 8 for both islands.

The average distance from the shoreline increased in the order of American widgeon, pintail, lesser scaup, mallard, white-winged scoter, and gadwall on island A, and American widgeon, lesser scaup, white-winged scoter, pintail, gadwall, and mallard on island C. An analysis of variance for nest distances to water showed no significant difference between islands A and C, or

Fig. 8. Distances of waterfowl nests from the shores of islands A and C.



lesser scaup
gadwall
pintail
white-winged scoter
mallard
American widgeon
range
mean
standard deviation
Distance of nest from water (in feet)
0
20
40
60
80
100
120
140
160
180
200
220
Island A
Island C



among the six species of waterfowl involved. The islands were probably of insufficient size to permit species to segregate significantly. Nevertheless, I believe there was a tendency for lesser scaup and gadwall to segregate in response to preferred vegetation for nesting purposes. This is best exemplified on island A. The majority of lesser scaup nested nearer the shoreline on island A than did gadwalls. Bent (1923) states that lesser scaup almost invariably nest in grasses, while gadwalls prefer heavier herbaceous cover. Miller and Collins (1954) similarily found that lesser scaup prefer grasses for nesting purposes. They also state that gadwalls select drier nest sites, which on island A are the more interior portions. Gates (1962) describes gadwalls as nesting primarily in the densest, driest cover. The shoreline of island A is dominated by grasses with some grassy areas interspersed with the interior vegetation. Dense stands of herbaceous cover are restricted essentially to the higher, innermost areas of the island, while small isolated patches of herbaceous plants also grew on the lower contours. Since gadwalls occasionally nested in herbaceous cover situated on the lower portions of island A, the position of vegetation seems responsible for the segregation between lesser scaup and gadwall. The less obvious segregation between lesser scaup and gadwalls, and all other species on island C, can be explained by the lack of nesting cover. The high gull population reduced nesting

cover forcing waterfowl to nest closer together. This would mask any potential difference between species that may have resulted had all the island been equally attractive for nesting purposes and of a sufficient size to allow species to segregate.

4.3 Trapping Success

During the 3-year study a total of 107 nesting female waterfowl were trapped and banded. Of these, 3 were banded on peninsula B and 104 on islands A and C (Table 3).

Throughout the period of study the number of non-banded females caught decreased, with the percentages of the total nesting population on island A falling from 57 to 42 per cent between 1965 and 1967. This reflects changes in population levels and proportions of banded individuals on the island. In 1966, 26 females were trapped. Of these, 16 were unbanded and 10 were recaptures of birds trapped and banded in 1965. Similarly in 1967, 21 were trapped, of which 14 were unbanded and 7 were recaptures from 1966 and 1967 (Table 3). If the total number of females trapped is considered, then 57, 55, and 64 per cent of the total nesting population were handled in 1965, 1966, and 1967, respectively (Table 4). The values for island C, calculated on the same basis, are 42, 20, and 52 per cent, respectively.

With the exception of 1966 on island C, the percentages of the total population trapped remained relatively constant.

Table 3. Banding and recapture records of female waterfowl handled on islands A and C in 1965, 1966, and 1967.

Species	No. females newly banded							No. females recaptured after one year*					No. females recaptured after two years**		
	Islands							Islands					Islands		
	A			C			Total	A		C		Total	A	C	Total
	1965	1966	1967	1965	1966	1967		1966	1967	1966	1967		1967	1967	
lesser scaup	24	7	2	14	3	7	57	5	2	2	0	9	2	2	4
gadwall	2	6	6	3	0	0	24	5	0	0	0	5	1	1	2
mallard	2	0	2	2	0	2	8	0	0	1	0	1	1	0	1
pintail	1	1	1	2	0	1	6	0	0	0	0	0	0	1	1
white-winged scoter	0	1	3	2	0	2	8	0	0	0	0	0	0	0	0
American widgeon	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0
Total	36	16	14	23	3	12	104	10	3	3	0	16	4	4	8

*females banded in 1965 and recaptured in 1966, and females banded in 1966 and recaptured in 1967.

**females banded in 1965 and recaptured in 1967.

Table 4. Success in trapping nesting waterfowl on islands A and C from 1965 through 1967.

Year	Island A			Island C		
	Total No. nests	No. ♀♀ trapped	% ♀♀ trapped	Total No. nests	No. ♀♀ trapped	% ♀♀ trapped
1965	63	36	57	55	23	42
1966	47	26	55	30	6	20
1967	33	21	64	31	16	52
Total	143	83	58	116	45	39

Two factors possibly contributed to low trapping success on island C in 1966. These were the alarm calls emitted by gulls when I approached the colony, and my trapping techniques.

In 1965 the bow-trap was used successfully on both islands A and C. Approximately 100 feet of cord was run from the trap-springing mechanism to the point from where the trap was sprung. This was sufficient to enable me to approach the incubating duck, spring the trap, and capture it. In 1966 on island C, this length of cord was insufficient. This I attribute to the higher noise level of the alarm calls given by the increased population of gulls in 1966. This afforded waterfowl the opportunity to leave their nests before I was within 100 feet.

Gull populations remained relatively stable on island C in 1967, as compared to 1966, but my trapping success increased by 32 per cent (Table 4), probably as a result of increasing the length of the trip cord from 100 feet to over 300 feet. This enabled me to spring the trap from the periphery of the island, where I was at some distance from the gull colonies, thus delaying the onset of alarm calling.

4.4 Survival and Homing

Through marking of individuals, information on survival rates and homing capabilities can be determined. However, if the use of such marking techniques is to

provide valid results, certain assumptions must be made (Adams, 1951; Farner, 1955). These are: that banded individuals suffer the same mortality as those unbanded; that sampling procedures are random and unbiased; and that the loss of bands is insignificant.

A total of 59 female waterfowl were trapped and banded at their nest sites on islands A and C in 1965 and 19 in 1966. Survival based only on birds retrapped indicated that 16 (21 per cent) were recaptured on their nests one year after banding and 8 (14 per cent) after two years (Table 3). Since these survival figures are based only on birds banded and retrapped, and since the untrapped portion of the nesting population probably held previously banded individuals, the per cent return recorded represents minimum survival in the population.

The calculation of annual survival rates is based on the supposition that banded survivors are distributed proportionately between the trapped and untrapped segments of the island populations. Table 5 is a summary of the calculated survival of banded female waterfowl on islands A and C throughout the study. Because sufficient samples were not available to permit treatment of individual species, all six waterfowl species were combined. It should be noted that the resulting calculations, based on these six species, are probably more representative of lesser scaup and gadwall through their preponderance in the sample. A survival rate of 0.68

Table 5. Calculated survival of banded female waterfowl handled during the study period on islands A and C.

Year	No. ♀♀ nesting		No. ♀♀ trapped		No. ♀♀ newly banded		No. ♀♀ known alive 1 year after banding		No. ♀♀ known alive 2 years after banding		No. banded on islands** (A and C)	
	Islands		Islands		Islands		Islands		Islands		After 1 year	After 2 years
	A	C	A	C	A	C	A	C	A	C		
1965	63	55	36	23	36	23	-	-	-	-	-	-
1966	47	30	30*	10*	16	3	14*	7*	-	-	40	-
1967	30	31	21	16	14	12	3	0	4	4	6	15

(continued)

Table 5. (continued)

Year	Survival rate islands A and C **		No. ♀♀ surviving from those banded**			
	After 1 year	After 2 years	After 1 year		After 2 years	
			Islands A	Islands C	Islands A	Islands C
1965	-	-	-	-	-	-
1966	0.68	-	24	16	-	-
1967	0.32	0.25	5	1	9	6

*these figures include individuals banded in 1965 and recaptured in 1967 as these were alive in 1966 (Table 3)

**see Appendix 3 for methods used in calculations

was obtained between the years 1965 and 1966, and 0.32 between 1966 and 1967.

Farner (1955) summarized the survival rates of three waterfowl species as calculated by a number of workers. The species studied included primarily mallards, black ducks (*Anas rubripes*), and blue-winged teal (*A. discors*). Survival rates ranged from 0.35 to 0.60 after one year, with a mean survival of 0.46. Hickey (1952) found the survival rate in redheads to be 0.55 after one year. Sowls (1955) calculated a survival rate for pintails of approximately 0.50. These survival rates are lower than the 0.68 recorded in 1966 at Miquelon Lake. This may be due to either the limited samples from the islands, or differences in species composition. Hochbaum (in Sowls, 1955) found that mallards made up 58 per cent of the harvest by hunters between the years 1938 and 1941, and 1946 and 1950. If hunting pressure on mallards increased mortality rates, the low survival observed in Farner's summary would be expected. According to Hochbaum lesser scaup and gadwall received less hunting pressure than mallards. This being the case a higher survival in these two species would be expected. Since lesser scaup and gadwall comprised 55 and 23 per cent of the total banded population, respectively, the estimated high survival of 0.68 may in fact approach reality. However, the 1967 rate drops to 0.32. This decrease in survival may be due to the fact that in 1966 only 19 (25 per cent) nesting females were newly

banded out of the total population for 1966. In 1965, however, 59 (50 per cent) females were newly banded out of the total waterfowl population. Without a large sample of newly banded females from 1966 available for retrapping in 1967 the calculated survival rate is probably less accurate.

In order to establish the extent of homing in the island populations, the number of banded females returning must be compared to the number surviving from the previous year.

Data on the return of banded females to the island study areas, based on survival rates in Table 5, are presented in Table 6. It should be noted that the percentage returns in Table 6 are, at best, minimum values. A number of banded female waterfowl were observed nesting on the islands but were not retrapped for one reason or another. Throughout the study only birds banded during this study were retrapped on the islands. Therefore, it is possible to assume that the banded females observed were from the population being studied. If this were the case the return of females was actually higher than calculated on both islands A and C.

In 1966 the return of banded females to island A, from the previous year, was 23 per cent greater than returns to island C. The figures in 1966 and 1967 may not provide a true picture of the actual return because of the small sample banded and trapped in 1966.

Table 6. Return of banded waterfowl to islands A and C based on calculated survival rates.

	No. banded females surviving 1 year after banding, Islands		No. banded females surviving 2 years after banding, Islands		% banded females returned 1 year after banding, Islands		% banded females returned 2 years after banding, Islands	
	A	C	A	C	A	C	A	C
1966	24	16	-	-	42(10/24)*	19(3/16)	-	-
1967	5	1	9	6	60(3/5)	0(0/1)	44(4/9)	67(4/6)

*figures in parentheses represent the number of females recaptured out of the total number surviving

It is evident from Table 6 that the return after two years is relatively high on islands A and C. Return on island C was 23 per cent greater than on island A. This could imply that the homing tendency was stronger in female waterfowl which inhabited island C. A number of other possible explanations may be considered: 1) an insufficient sample was obtained; 2) island C may possess stronger attractive forces than island A; 3) it may reflect human presence on island A.

These banding and recapture data suggest that a high proportion of the females do return to the islands to nest in subsequent years, as long as they survive.

4.5 Date of Clutch Initiation and Hatch

Whether or not meteorological conditions play a significant role in determining the time of nest initiation in waterfowl is still rather controversial. Mendall (in Keith, 1961) while working with a population of ring-necked ducks (*Aythya collaris*) in Maine, indicated that cold weather or excessive precipitation will cause nesting to be delayed, while high temperatures will promote the onset of nesting at earlier than average dates. Low's (1945) observations in Iowa on redheads were comparable to those of Mendall. Low found that nest initiation followed soon after warm weather in late April and early May. Keith (1961), working in southern Alberta, investigated the relationship between the date of nest initiation and

maximum, minimum, or mean temperatures, and precipitation. He found no consistent relationship between any of these meteorological factors and the onset of nesting.

Because of the lack of agreement on the role of temperature in controlling the onset of nesting, I investigated the situation at Miquelon Lake for two species of early nesters, mallards and pintails.

Figs. 9, 10, and 11 depict the onset of nesting and hatching on the islands for 1965, 1966, and 1967, respectively. The beginning of nesting for mallards and pintails varied from year to year. In 1965 the first nest was initiated during the first week of May, in 1966 during the third week of May, and in 1967 during the second week of May. A comparison of mean dates of nest initiation with the average maximum, minimum, and mean temperatures, and precipitation for the period April 15 to May 15 appear in Table 7.

From 1965 to 1967 temperatures decreased in each of the three categories. However, there was no constant increase in the delay of nest initiation throughout the study. In 1966 the average maximum, minimum, and mean temperatures, from April 15 to May 15 decreased by 1.7°F, 1.9°F, and 1.8°F, respectively, from 1965. Over this same period mallards nested 13 days later than in 1965 and pintails 5 days later. In 1967 the average maximum, minimum, and mean temperatures decreased by 6.2°F, 3.2°F, and 4.7°F, respectively, from 1966 readings. However,

Fig. 9. Dates of clutch initiation and hatching for waterfowl found nesting on islands A and C in 1965.

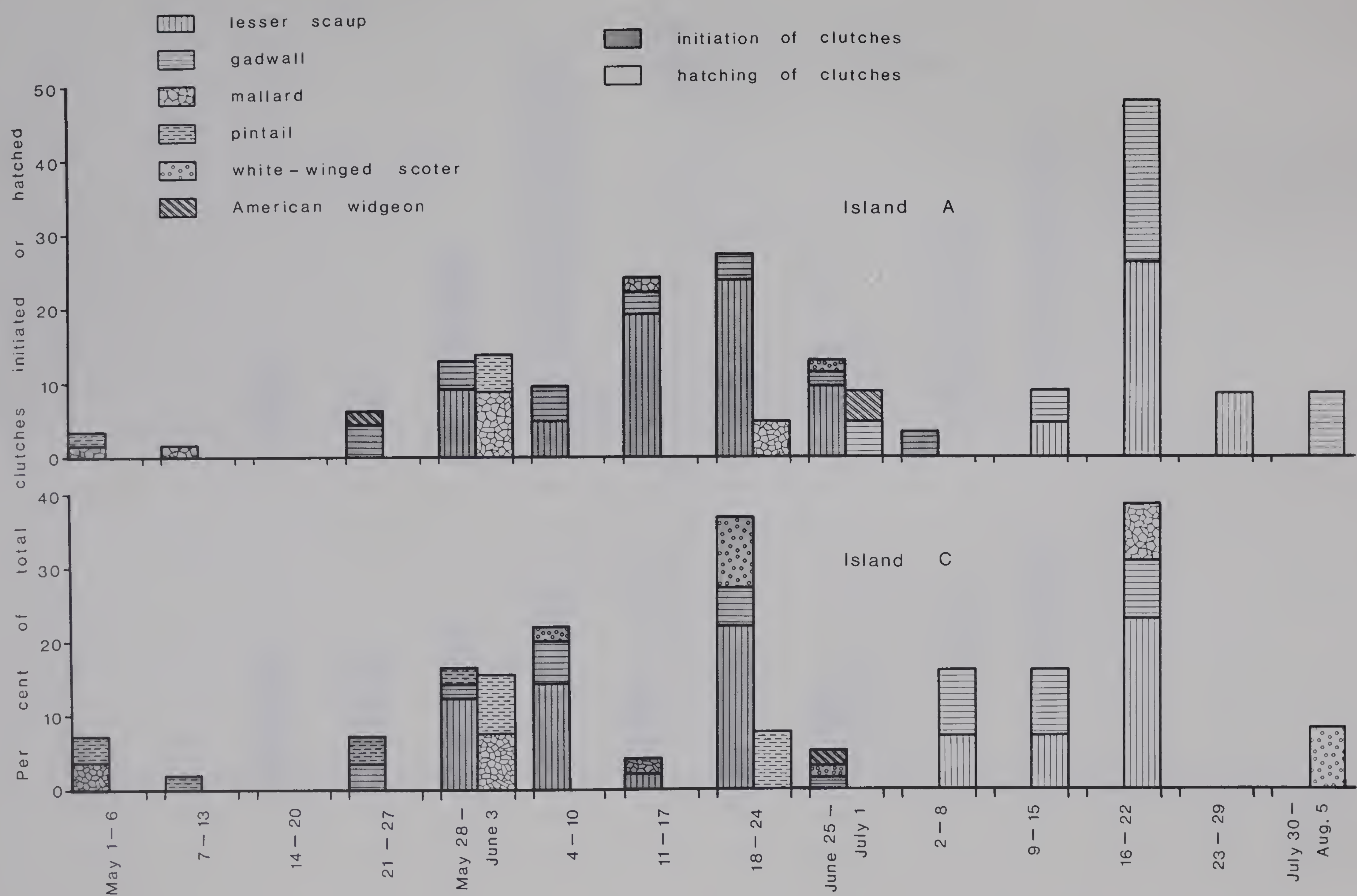
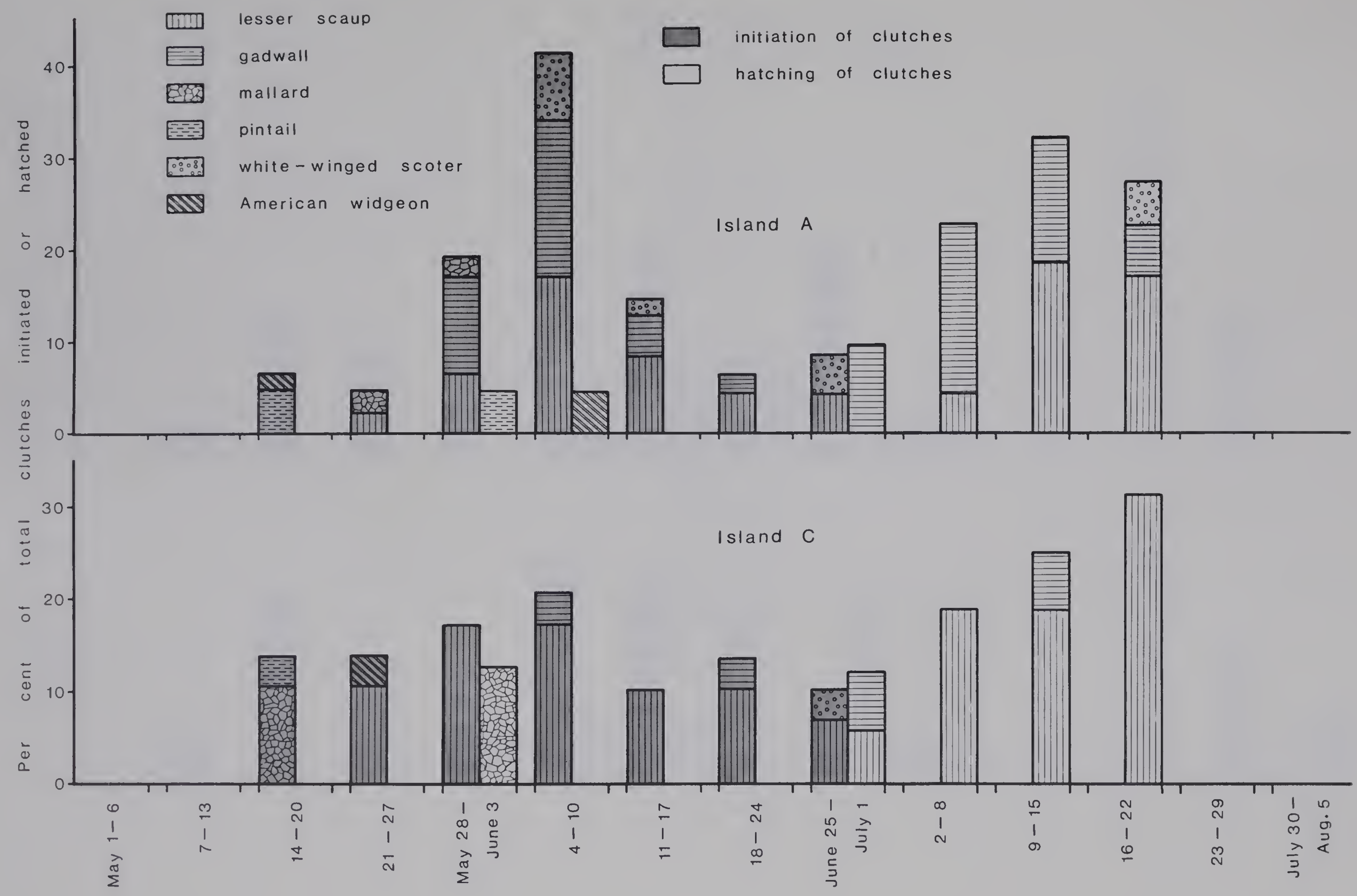

lesser scaup
gadwall
mallard
pintail
white-winged scoter
American widgeon
initiation of clutches
hatching of clutches
Island A
Island C
Per cent of total clutches initiated or hatched
50
40
30
20
10
0
May 1 – 6
7 – 13
14 – 20
21 – 27
May 28 – June 3
4 – 10
11 – 17
18 – 24
June 25 – July 1
2 – 8
9 – 15
16 – 22
23 – 29
July 30 – Aug. 5

Fig. 10. Dates of clutch initiation and hatching for waterfowl found nesting on islands A and C in 1966.



lesser scaup
gadwall
mallard
pintail
white-winged scoter
American widgeon
initiation of clutches
hatching of clutches
Island A
Island C
Per cent of total clutches initiated or hatched
0
10
20
30
40
May 1 – 6
7 – 13
14 – 20
21 – 27
May 28 – June 3
4 – 10
11 – 17
18 – 24
June 25 – July 1
2 – 8
9 – 15
16 – 22
23 – 29
July 30 – Aug. 5

Fig. 11. Dates of clutch initiation and hatching for waterfowl found nesting on islands A and C in 1967.

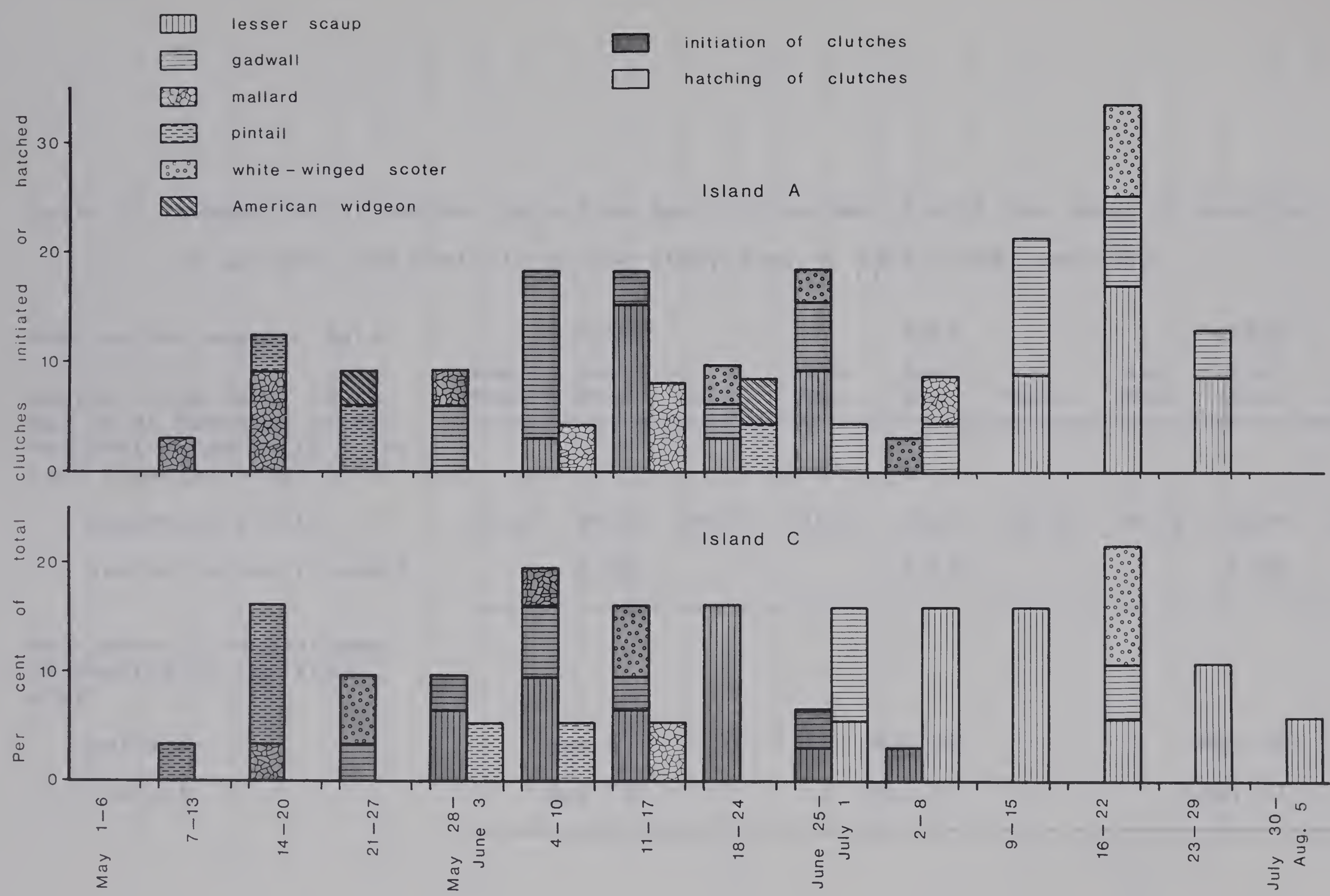

lesser scaup
gadwall
mallard
pintail
white - winged scoter
American widgeon
initiation of clutches
hatching of clutches
Island A
Island C
clutches initiated or hatched
Per cent of total
0
10
20
30
May 1–6
7–13
14–20
21–27
May 28–June 3
4–10
11–17
18–24
June 25–July 1
2–8
9–15
16–22
23–29
July 30–Aug. 5

Table 7. Comparison of weather data from April 15 to May 15 with the onset of nesting in mallards and pintails on the study area in 1965, 1966, and 1967.

Nesting and weather data	1965			1966			1967		
	Ave. Max.	Ave. Min.	Mean	Ave. Max.	Ave. Min.	Mean	Ave. Max.	Ave. Min.	Mean
Weather from April 15 to May 15 at Edmonton International Airport (25 miles from Miquelon Lake)									
temperature (°F)	54.9°	34.5°	44.7°	53.2°	32.6°	42.9°	47.0°	29.4°	38.2°
precipitation (inches)		0.58			0.45			0.48	
Mean date of commencement of nesting on the study area									
mallard		May 6			May 19			May 16	
pintail		May 12			May 17			May 17	

mallards nested 3 days earlier and pintails on the same day as they did in 1966.

Mendall (in Keith, 1961) suggested that increased precipitation will delay nesting by waterfowl. On the islands of Miquelon Lake, in 1965, 0.58 inches of precipitation fell, the highest recorded during the study for the period April 15 to May 15. However, the earliest date of nesting occurred in that year. Similarly, the lowest amount of precipitation fell in 1966 when the onset of nesting was the latest observed. Precipitation at the levels recorded, therefore, did not seem to be of any significance in determining the onset of nesting.

There appears to be no consistent relationship between the commencement date of nesting in mallards and pintails and any of the three temperature groupings or precipitation. These observations at Miquelon Lake are in agreement with those obtained by Keith (1961). However, the possibility of a complex interrelationship existing between these phenomena cannot be totally ruled out on the basis of these data alone. A larger sample size over a longer period of time is needed to clarify this point.

Lesser scaup and white-winged scoters were usually the last species to begin nesting; however, gadwalls did, on occasion, initiate nests fairly late in the season. Some of the late nesters, particularly in the first full week of July (Figs. 9 and 11), may have been birds attempting to renest. It is possible that some of the

dates of nest initiation recorded throughout the season were actually second nests. Ducks which lost their clutches early in incubation or laying may have initiated a second nest. I was not able to determine the extent of renesting as birds were not marked during the early stages of incubation for fear of nest desertion. In 1965, however, I did manage to retrap a lesser scaup and a mallard on their second nest. These were the only proven instances of renesting on the islands though renesting probably occurred frequently. Sowls (1949) found renesting to be a common occurrence among waterfowl. He recorded one female shoveler (*Spatula clypeata*) attempting to nest three times in one summer.

The general nest initiation trend as seen in Figs. 9, 10, and 11 will produce a similar trend in the dates of hatching, which are also depicted on these figures. Two periods of hatching were observed. These were roughly in the early and mid parts of June and late July. To determine whether data on hatching on the islands were similar to thoseobserved in other areas near Miquelon Lake, records for 1966 and 1967 were obtained from Ducks Unlimited and the Alberta Fish and Wildlife Division, respectively. Ducks Unlimited carries out brood censuses near Ministik Lake, while Fish and Wildlife Division data are representative of the Camrose area in general. Circumstances were such that data for both years were not obtainable from one source. A comparison of hatching

dates on the islands of Miquelon Lake and from the two other sources appear in Figs. 12 and 13. The Ducks Unlimited sample included 226 broods and the Wildlife Division sample consisted of 202 broods. Considering that these figures were compared to 38 and 43 hatched broods on the islands, respectively, the general trends on the islands for both 1966 and 1967 appear to be quite similar to those observed in census data. The only marked discrepancy is seen in the second week of June, 1967. However, in census data for that year a high number of mallard and American widgeon broods were observed during that particular week. On the islands these two species were not very abundant. Therefore, a high number of these species in census data would tend to raise the per cent hatch considerably higher than that observed in my island data.

Basically, the hatching dates for waterfowl on the islands followed the general trend observed in the vicinity of Miquelon Lake.

4.6 Fate of Nests

Throughout the 3-year period records were kept on the status of each waterfowl nest located on the islands. The results of these observations appear in Table 8. Nests destroyed by predators were easily discerned. Those classed as "deserted for reasons unknown" were nests where no positive explanation could be found to account for the discontinuance of egg laying or incubation. Nests

Fig. 12. Comparison of the distribution of hatching dates for clutches on the islands of Miquelon Lake and those obtained in the Ministik Lake area by Ducks Unlimited in 1966.

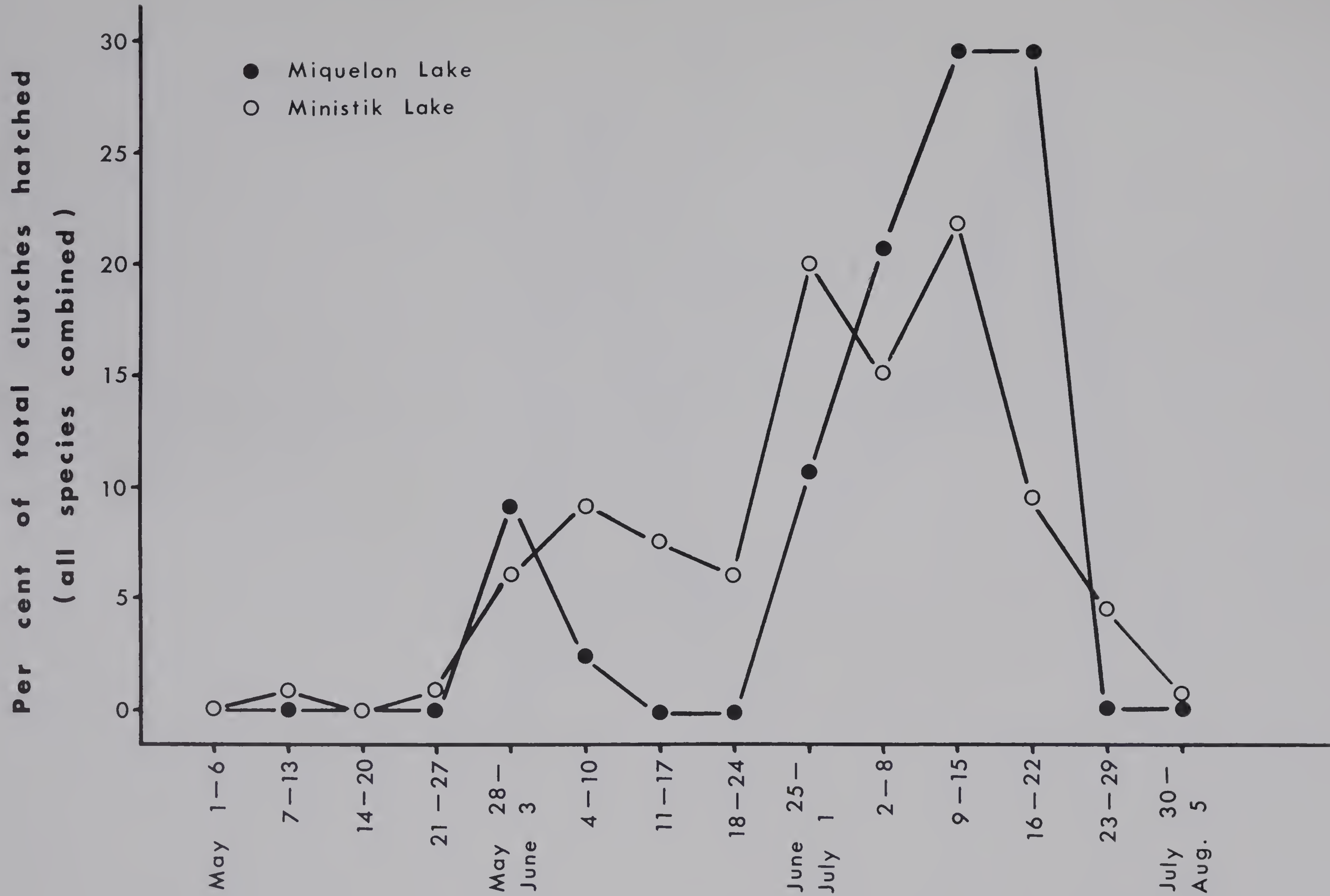
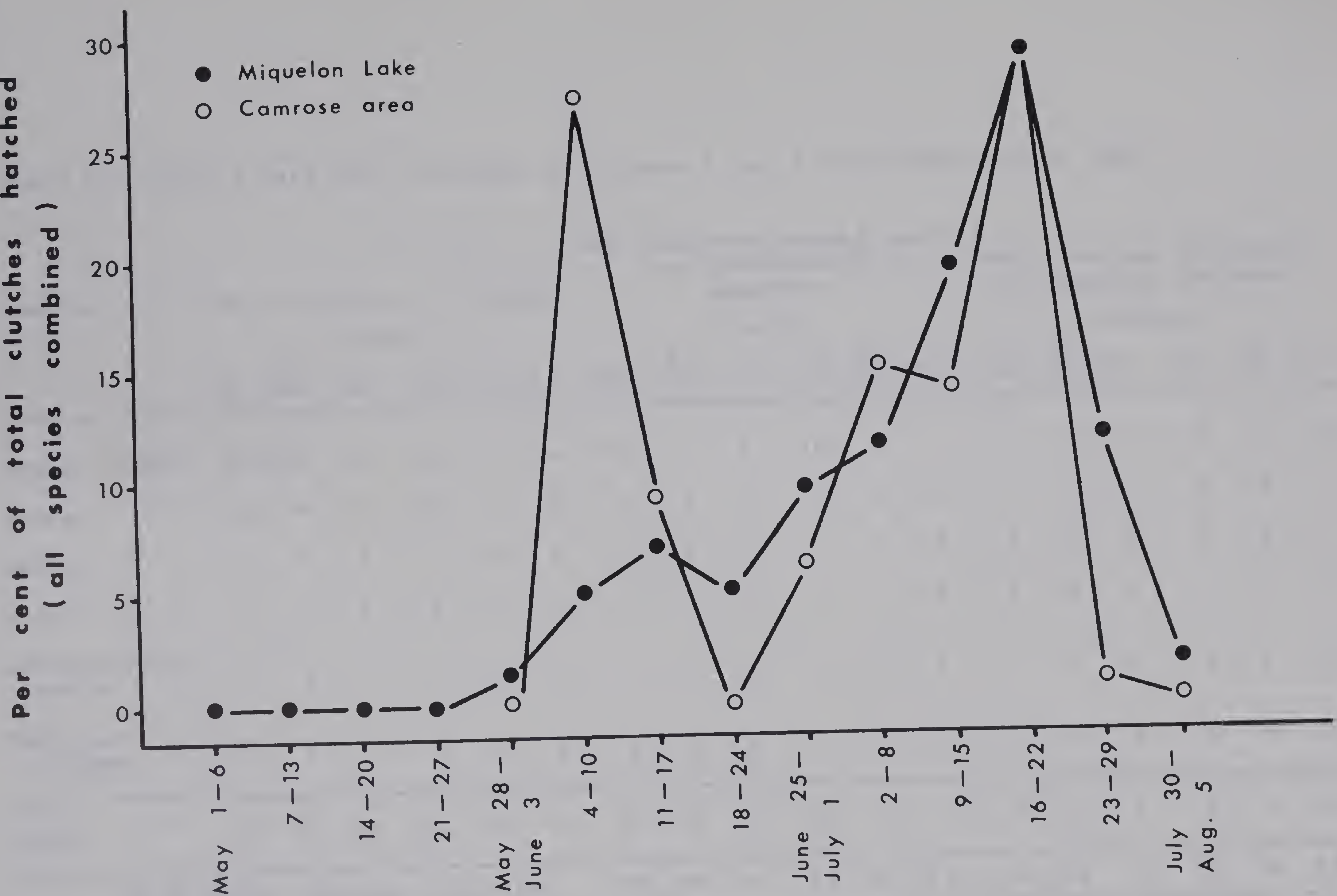

Per cent of total clutches hatched
(all species combined)
30
25
20
15
10
5
0
Miquelon Lake
Ministik Lake
May 1 – 6
7 – 13
14 – 20
21 – 27
May 28 – June 3
4 – 10
11 – 17
18 – 24
June 25 – July 1
2 – 8
9 – 15
16 – 22
23 – 29
July 30 – Aug. 5

Fig. 13. Comparison of the distribution of hatching dates for clutches on the islands of Miquelon Lake and those obtained in the vicinity of Camrose, Alberta, by the Alberta Division of Fish and Wildlife in 1967.


Per cent of total clutches hatched
(all species combined)
30
25
20
15
10
5
0
Miquelon Lake
Camrose area
May 1 – 6
7 – 13
14 – 20
21 – 27
May 28 – June 3
4 – 10
11 – 17
18 – 24
June 25 – July 1
2 – 8
9 – 15
16 – 22
23 – 29
July 30 – Aug. 5

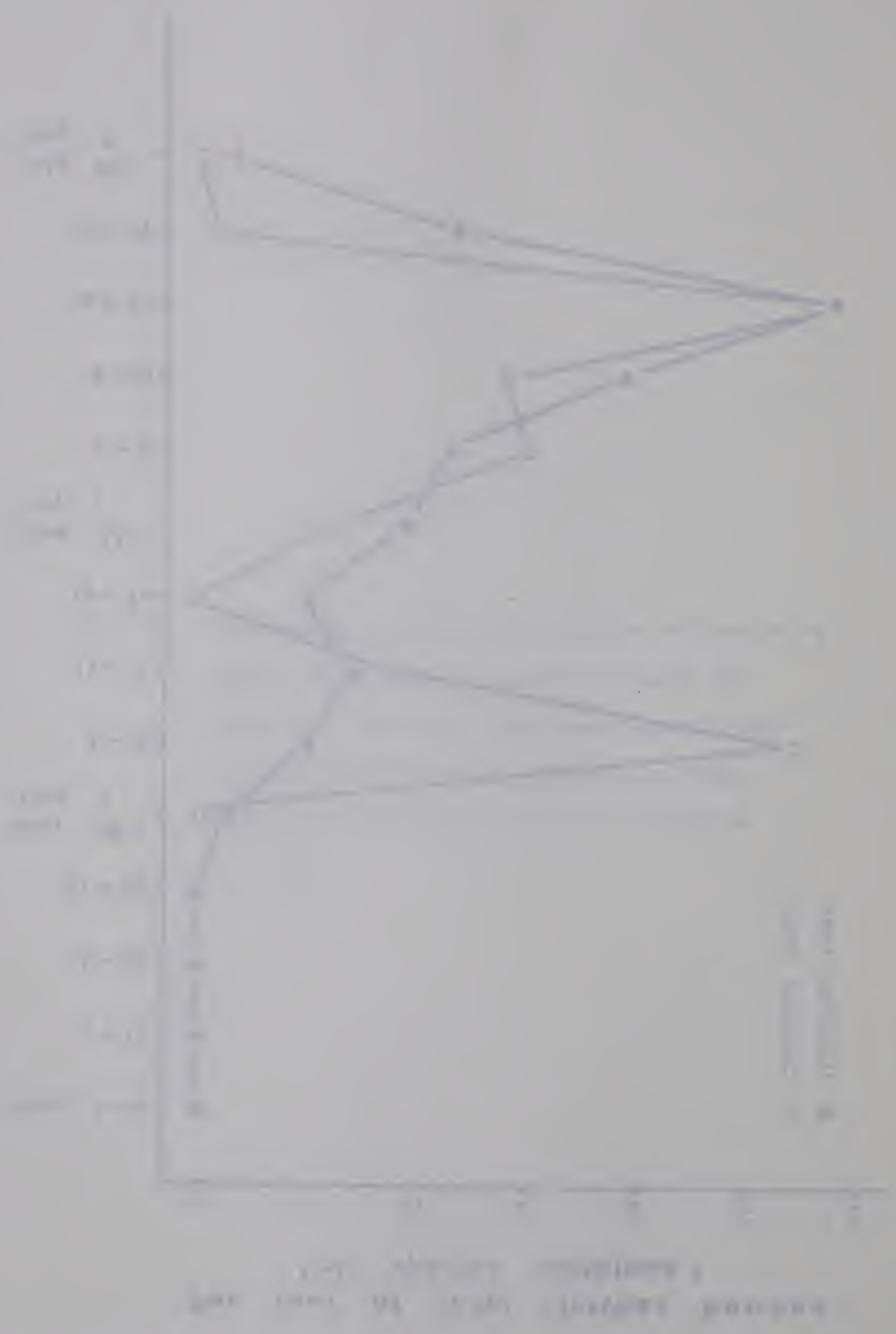


Table 8. Fate of waterfowl clutches on islands A and C from 1965 through 1967.

Species	No. clutches initiated						No. clutches preyed upon and subsequently deserted						No. clutches deserted for reasons unknown					
	Islands						Islands						Islands					
	A			C			A			C			A			C		
	'65	'66	'67	'65	'66	'67	'65	'66	'67	'65	'66	'67	'65	'66	'67	'65	'66	'67
lesser scaup	42	20	10	28	21	14	19	7	2	16	5	3	5	3	0	3	3	0
gadwall	15	16	11	10	2	6	4	3	2	5	0	2	1	1	1	2	0	1
mallard	3	2	5	3	3	2	0	2	1	1	1	0	0	0	0	0	0	1
pintail	1	2	3	6	1	5	0	1	2	4	1	0	0	0	0	0	0	2
white-winged scoter	1	6	3	7	1	4	1	3	0	2	1	2	0	2	0	3	0	0
American widgeon	1	1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
Total	63	47	33	55	29	31	24	16	7	29	9	7	6	6	1	8	3	4
% of total clutches initiated							38	34	21	53	31	23	10	13	3	15	10	13

(continued)

Table 8. (continued)

Species	No. clutches deserted subsequent to banding of female						No. clutches hatched					
	Islands						Islands					
	A			C			A			C		
	'65	'66	'67	'65	'66	'67	'65	'66	'67	'65	'66	'67
lesser scaup	9	1	0	4	1	0	9	9	8	5	12	11
gadwall	1	2	0	0	0	0	9	10	8	3	2	3
mallard	0	0	0	0	0	0	3	0	4	2	2	1
pintail	0	0	0	0	0	1	1	1	1	2	0	2
white-winged scoter	0	0	1	1	0	0	0	1	2	1	0	2
American widgeon	0	0	0	0	0	0	1	1	1	0	0	0
Total	10	3	1	5	1	1	23	22	24	13	16	19
% of total clutches initiated	16	6	3	9	3	3	37	47	73	24	55	61

abandoned as a result of banding were classified as such if the female failed to return to her nest after being handled. However, if a female was banded and subsequently returned to continue incubation for some period of time, then was found to have left the nest permanently, this nest was classified as "deserted for reasons unknown".

It is interesting to note that the total percentages of the various causes of nest desertion generally decrease, in the majority of cases, from 1965 to 1967 inclusive. As a result, the overall hatching success on islands A and C increased throughout this period.

The decrease in loss of nests through banding was due to increased efficiency in banding operations. In 1965, and to a lesser extent in 1966, I relied almost exclusively on the number of days a particular nest had been incubated to determine the time of trapping. In many cases trapping at 21-22 days of incubation still resulted in desertion of nests. In 1967 the majority of females were trapped when the first sign of pipping was evident. Although some nests were still abandoned even at this late stage, this method proved more efficient and resulted in more females returning to the nest site to complete hatching of their clutches.

Fluctuations in nest losses as a result of unknown causes occurred from year to year on both islands A and C. One factor involved in this form of nest loss could be female mortality during the laying or incubation stages. Another possible influence may be human intrusion near the

nest site during laying or early incubation. The inconsistency of young birds initiating their first nest and adverse weather conditions may similarly induce a female to forsake her nest (Kalmbach, 1939).

Predation on the study area was the most significant cause of nest desertion during each of the three seasons. A decrease in the proportion of nests that were lost to predators was recorded throughout the study. A more extensive treatment of both nest and brood predation, along with other associated factors, will be presented in separate sections.

Very few nests were initiated on peninsula B during the study. In 1965, 4 lesser scaup and 3 pintails attempted to nest there. Only 1 lesser scaup clutch hatched, the others being destroyed through predation or trampling of cattle. In 1966, 4 lesser scaup nested on the B complex. Three clutches were preyed upon and 1 hatched. Only 2 nests, a gadwall and mallard, were initiated on this area in 1967. Cattle destroyed the gadwall nest, but the mallards hatched successfully.

The total number of nests occupied to the time of hatch remained relatively constant from 1965 to 1967 on both islands A and C (Table 8). However, the percentages which these numbers represented, of nests initiated, increased significantly over the three years. The increase in success appears to be correlated with the significant decline in loss of nests to predators.

When the data on hatching success from islands A and C are combined, the total percentage of clutches hatching increased from 31 to 50 to 67 per cent for the years 1965, 1966, and 1967, respectively (Table 9). Kalmbach (1939) summarized hatching success at 60 per cent from 22 separate field-studies. His data included some 7600 nests from 13 species of waterfowl. Kalmbach considered this success good for waterfowl studied under various environmental conditions. In the present study poor hatching success recorded in 1965 and 1966 can be attributed to relatively high predation. In 1967 hatching success increased to 67 per cent which can be considered good by Kalmbach's standards.

Because of limited sample sizes, waterfowl were lumped into two categories: "diving" and "dabbling" (Table 10). A comparison of hatching success in these two categories was then made. The mean hatching success for dabblers was 57 per cent and for divers 46 per cent. Dabbling ducks were only slightly more successful in hatching their eggs at Miquelon Lake. The low success of divers during two years of the study may be attributed to the extremely low success of white-winged scoters (Table 9). The highest hatching success for both dabbling and diving ducks was recorded in 1967 when losses through avian predation was the lowest recorded.

Keith (1961) summarized the per cent hatch in dabbling and diving ducks from six studies on the Canadian prairies.

Table 9. Hatching success of waterfowl clutches laid on islands A and C in 1965, 1966, and 1967.

Species	No. clutches initiated			No. clutches hatched			% hatched		
	1965	1966	1967	1965	1966	1967	1965	1966	1967
lesser scaup	70	41	24	14	21	19	20	51	79
gadwall	25	18	17	12	12	11	48	67	65
mallard	6	5	7	5	2	5	83	40	71
pintail	7	3	8	3	1	3	43	33	38
white-winged scoter	8	7	7	1	1	4	13	14	57
American widgeon	2	2	1	1	1	1	50	50	100
Total	118	76	64	36	38	43	31	50	67

Table 10. Hatching success for dabbling and diving ducks on islands A and C from 1965 to 1967, inclusive.

Category	Hatching success (%) 1965	1966	1967	Mean hatching success (%)
dabblers	53	57	61	57
divers	19	46	74	46

An average of 39 per cent of the nests of dabbling and 56 per cent of diving ducks hatched successfully. The over-water nesting habit of many species of diving ducks decreased their vulnerability to mammalian predators in comparison to the terrestrially nesting dabbling species. Mammalian predators were in abundance in the studies Keith summarized but were absent from the islands in the present study. This fact probably explains the differences between his and my results.

From these data it appears that nesting success of waterfowl on the islands of Miquelon Lake increased as their numbers declined. If the success of waterfowl in nesting is directly associated with the activity of predator populations, then an effective negative feedback phenomenon exists. As the number of waterfowl nests decline the effort expended per meal by a predator increases. This assumes a threshold density for the prey. The response of a predator when this threshold is reached would be to abandon extensive searches for nests and locate a more easily obtainable food source elsewhere. This type of a functional response on the part of the predator accounts for the greater proportion of nests hatching in 1967. Keith (1955) obtained similar results in southern Alberta. Hammond (1940) concluded that the amount of crow predation on his study areas was partially dependent upon the density of waterfowl nests. As the density of nests increased crow predation similarly increased and a greater proportion

of nests were lost. In the present study crows were suspected of being one of the major avian predators. Therefore, the nest density-predator activity relationship probably operated on the island study areas.

4.7 Clutch Statistics

In determining the mean clutch size for each species of waterfowl only clutches that hatched were considered. Eggs deposited in nests of ducks of one species by ducks of a different species were excluded from clutch statistics. No corrections were made, however, to account for eggs possibly deposited by other members of the same species. It was difficult to determine the extent of intraspecific nest parasitism. Consequently, average clutch sizes may be slightly higher than normal for some species.

Table 11 summarizes egg and duckling production by successful individuals of the six species of waterfowl nesting on the study area at Miquelon Lake.

No significant variation in clutch sizes were recorded between years of the investigation for any of the species studied.

Table 12 presents a comparison of the average clutch size for all species, except white-winged scoters, studied at Miquelon Lake and those reported in the literature. There is no significant difference in clutch size between any of these studies.

The average clutch size for white-winged scoters

Table 11. Average number of waterfowl eggs laid and hatched on islands A and C and peninsula B through the study period.

Species and year		No. nests	Ave. clutch size	Range	Ave. No. eggs hatched per nest	Range
	1965	15	8.3	6-11	6.7	3-10
lesser scaup	1966	22	10.0	5-18	8.4	3-13
	1967	19	9.7	5-17	9.2	4-17
	1965	12	8.3	6-10	6.1	1- 9
gadwall	1966	12	8.8	7-11	6.7	3-10
	1967	11	9.0	5-11	8.4	5-11
	1965	5	9.2	8-11	8.4	6-10
mallard	1966	2	9.5	9-10	9.5	9-10
	1967	6	8.7	7-12	5.7	1- 9
	1965	3	8.7	6-11	6.7	4- 8
pintail	1966	1	9.0	--	9.0	--
	1967	3	9.7	5-13	6.3	1-12
	1965	1	8.0	--	4.0	--
white-winged	1966	1	9.0	--	8.0	--
scoter	1967	4	8.0	7-10	7.3	7- 8
	1965	1	6.0	--	5.0	--
American	1966	1	11.0	--	9.0	--
widgeon	1967	1	10.0	--	8.0	--

Table 12. Summary of clutch sizes from four nesting studies.

Species	Authority	No. clutches	Total No. eggs laid	Ave. clutch size
	this study 1965-1967	56	527	9.4
lesser scaup	Rienecker and Anderson (1960)	19	209	11.0
	Miller and Collins (1954)	9	96	10.7
	this study 1965-1967	35	304	8.7
gadwall	Rienecker and Anderson (1960)	242	2650	11.0
	Miller and Collins (1954)	344	3834	11.1
	Anderson (1965)	8	77	9.6
	this study 1965-1967	13	117	9.0
mallard	Rienecker and Anderson (1960)	316	2804	8.9
	Miller and Collins (1954)	178	1578	8.9
	Anderson (1965)	11	104	9.5
	this study 1965-1967	7	64	9.1
pintail	Rienecker and Anderson (1960)	196	1556	7.9
	Miller and Collins (1954)	41	376	9.2
	Anderson (1965)	28	228	8.1
American widgeon	this study 1965-1967	3	27	9.0
	Rienecker and Anderson (1960)	2	20	10.0
	Anderson (1965)	2	18	9.0

was 8.1. This figure seems low in view of the normal clutch for the species as reported by Bent (1925). He states it varies from approximately 9 to 14 eggs.

A comparison of number of eggs laid with the number hatched per clutch shows that not every egg laid hatches (Table 11). Subsequent to clutch completion, eggs are lost through a number of agents. Table 13 summarizes the fate of eggs during this period for waterfowl studied at Miquelon Lake.

Unhatched eggs were opened and classified as either being "infertile" or containing a "dead embryo". Criteria used in classifying eggs were similar to those employed by Kossack (1950).

The disappearance of eggs from nests during incubation is not unusual (Sowls, 1955). Either predators or the incubating female may break and remove eggs (Sowls, 1955).

The annual percentage of eggs laid which hatched compares favorably with other studies reported in the literature (Miller and Collins, 1954; Anderson, 1956, 1957; Steel *et al.*, 1956; Rienecker and Anderson, 1960) in which hatching success varied from 76.9 to 91.6 per cent.

Eggs lost through infertility, dead embryos, and predators or other causes decreased throughout the 3-year period. Consequently, the overall percentage of eggs hatched of the total laid increased (Table 13).

Table 13. Fate of eggs from nests in which some eggs hatched on islands A and C and peninsula B from 1965 through 1967.

Species and year		Eggs hatched		Eggs infertile		Eggs with dead embryo		Eggs lost through predation or unknown causes		Total	
		No.	%	No.	%	No.	%	No.	%	No.	%
lesser scaup	1965	100	80.6	7	5.6	10	8.1	7	5.7	124	100.0
	1966	184	84.0	14	6.4	12	5.5	9	4.1	219	100.0
	1967	175	95.1	4	2.2	4	2.2	1	0.5	184	100.0
gadwall	1965	73	73.7	15	15.2	4	4.0	7	7.1	99	100.0
	1966	80	75.4	9	8.5	4	3.8	13	12.3	106	100.0
	1967	92	92.9	4	4.1	2	2.0	1	1.0	99	100.0
mallard	1965	42	91.3	1	2.2	0	0.0	3	6.5	46	100.0
	1966	19	100.0	0	0.0	0	0.0	0	0.0	19	100.0
	1967	34	65.4	6	11.6	1	1.9	11	21.1	52	100.0
pintail	1965	20	76.9	1	3.8	1	3.8	4	15.5	26	100.0
	1966	9	100.0	0	0.0	0	0.0	0	0.0	9	100.0
	1967	19	65.5	7	24.2	3	10.3	0	0.0	29	100.0
American widgeon	1965	5	83.3	0	0.0	0	0.0	1	16.7	6	100.0
	1966	9	81.8	1	9.1	0	0.0	1	9.1	11	100.0
	1967	8	80.0	2	20.0	0	0.0	0	0.0	10	100.0
white-winged scoter	1965	4	50.0	4	50.0	0	0.0	0	0.0	8	100.0
	1966	8	88.9	1	11.1	0	0.0	0	0.0	9	100.0
	1967	29	90.6	3	9.4	0	0.0	0	0.0	32	100.0
Total	1965	244	79.0	28	9.0	15	4.9	22	7.1	309	100.0
	1966	309	82.8	25	6.7	16	4.3	23	6.2	373	100.0
	1967	357	87.9	26	6.4	10	2.5	13	3.2	406	100.0

The mean loss of eggs throughout the study for the three most common species (lesser scaup, gadwall, and mallard) was calculated at 13.4 per cent, 19.3 per cent, and 14.4 per cent of the total eggs laid in successful nests, respectively. When these figures are compared with the calculated average for the same three species as reported in the literature (Miller and Collins, 1954; Steel *et al.*, 1956; Anderson, 1957; Rienecker and Anderson, 1960; Duebbert, 1966)--9.6, 10.0, and 10.8 per cent, it is apparent that the average loss at Miquelon Lake is slightly higher. The lower success at Miquelon Lake may be attributed to a greater loss of eggs in all categories. For example, during the period 1965 through 1967 lesser scaup lost 4.7 per cent of their eggs through infertility, 5.3 per cent of the embryos died, and 3.4 per cent through predation and other causes. Steel *et al.* (1956) noted that the loss of eggs through these various causes over a 3-year period were 2.5 per cent, 0.0 per cent, and 0.0 per cent, respectively.

Anderson (1956) reported that 6.7 per cent of all eggs in 1953 were infertile and 6.5 per cent in 1954. Infertility of eggs studied at Miquelon Lake for all species ranged from 6.4 per cent in 1967 to 9.0 per cent in 1965--rates similar to those reported above. However, these rates are higher than the 2.2 per cent recorded by Rienecker and Anderson (1960) and 1.3 per cent by Miller and Collins (1954). I am unable to account for these variations.

Embryonic death claimed 4.9 per cent of the eggs in 1965, 4.3 in 1966, and 2.5 in 1967 (Table 13). These losses are lower than the 8.1 to 8.5 per cent loss recorded by Anderson (1956), but are comparable to 4.8 per cent loss observed by Steel *et al.* (1956).

The greatest loss of eggs as a result of embryonic death occurred in the nests of pintail in 1967. They suffered a loss of 10.3 per cent of the eggs incubated. A loss of 8.1 per cent of the eggs of lesser scaup occurred from this cause in 1965. If additional eggs were deposited in the nest after incubation had begun, fertile eggs, deposited by parasitic females would not hatch with the original clutch, having only partially developed embryos. Therefore, intraspecific nest parasitism may be suspected if eggs are lost through death of embryos. Miller and Collins (1954) concluded intraspecific nest parasitism occurred in some redhead and ruddy duck (*Oxyura jamaicensis*) nests, as they found that 24.8 per cent of all redhead and 28.1 per cent of all ruddy duck eggs contained dead embryos. Relatively few eggs failed to hatch as a result of embryonic death in the Miquelon Lake study. Furthermore, with the exception of three lesser scaup clutches in 1966 and one in 1967, no striking increases in clutch sizes were observed during the laying period. This suggests that if intraspecific nest parasitism did occur it was relatively rare.

In summary, the average clutch size recorded for the

populations of waterfowl nesting on the islands at Miquelon Lake did not change significantly throughout the study. Also, no differences exist between the average clutch size of individual species observed on the study area and those recorded in other investigations. The failure of eggs to hatch through infertility, dead embryos, and destruction by predators and other factors decreased over the 3-year period.

4.8 Brood Observations

By individually color-marking incubating ducks it was anticipated that the fate of broods could be followed through periodic resightings. Table 14 summarizes observations of broods associated with marked females for the years 1965, 1966, and 1967.

During the summer of 1965 a total of 29 marked females with broods left the islands. Of the 9 broods resighted, 8 were hatched on island A and 1 on island C. In 1966, 24 incubating females were marked and hatched clutches of eggs. Of these 10 were observed on the lake subsequently, 9 from island A and 1 from island C. Of 32 marked females with broods in 1967, 11 resighted were from island A and 5 from island C. The percentage of marked females resighted from island A always exceeded that from island C by 20 to 32 per cent. This difference in percentage suggests that broods from island C were subject to greater losses than broods from island A.

Table 14. Observations of broods hatched on islands A and C.

Species and year		No. marked females with broods from islands		No. marked females resighted from islands		Original No. ducklings in broods from islands	
		A	C	A	C	A	C
lesser scaup	1965	8	2	4	0	24	-
	1966	8	3	2	1	12	12
	1967	5	8	1	4	8	33
gadwall	1965	8	3	4	0	23	-
	1966	9	0	4	0	25	-
	1967	7	1	5	1	40	10
mallard	1965	2	2	0	1	0	9
	1966	0	1	0	0	-	-
	1967	3	1	3	0	16	-
pintail	1965	1	2	0	0	-	-
	1966	1	0	1	0	9	-
	1967	1	1	0	0	-	-
American widgeon	1965	0	0	0	0	-	-
	1966	1	0	1	0	9	-
	1967	1	0	1	0	8	-
white-winged scoter	1965	0	1	0	0	-	-
	1966	1	0	1	0	8	-
	1967	2	2	1	0	8	-

(continued)

Table 14. (continued)

Species and year		Per cent ducklings resighted at weeks after hatching							
		week 1		week 2		week 3		week 4	
		Islands		Islands		Islands		Islands	
		A	C	A	C	A	C	A	C
lesser scaup	1965	79(2)*	-	88(4)	-	100(1)	-	-	-
	1966	100(2)	17(1)	100(1)	-	89(1)	-	-	-
	1967	100(1)	61(4)	100(1)	94(2)	100(1)	-	-	-
gadwall	1965	94(3)	-	100(3)	-	85(2)	-	-	-
	1966	92(4)	-	67(1)	-	-	-	67(1)	-
	1967	85(5)	0(1)	100(3)	-	87(2)	-	-	-
mallard	1965	-	89(1)	-	89(1)	-	-	-	-
	1966	-	-	-	-	-	-	-	-
	1967	88(3)	-	-	-	100(1)	-	-	-
pintail	1965	-	-	-	-	-	-	-	-
	1966	-	-	-	-	89(1)	-	-	-
	1967	-	-	-	-	-	-	-	-
American widgeon	1965	-	-	-	-	-	-	-	-
	1966	-	-	-	-	78(1)	-	-	-
	1967	100(1)	-	100(1)	-	-	-	-	-
white-winged scoter	1965	-	-	-	-	-	-	-	-
	1966	100(1)	-	163(1)	-	-	-	-	-
	1967	100(1)	-	100(1)	-	-	-	-	-

*figures in parentheses indicate the number of broods involved

Vermeer (1967) reported that in 1964 gulls preyed heavily on ducklings as they left the islands in Miquelon Lake. Island C supported the higher gull population from 1965 to 1967. Therefore, waterfowl broods leaving that island would be more subject to the predatory activities of gulls than those from island A. I witnessed gulls capturing and devouring ducklings near the shores of island C, but never near either island A or at any other locality on the lake. Some broods did manage to leave island C successfully, others with slight to complete loss of ducklings. Marked females were observed on the lake without broods. A more complete treatment of predation on ducklings by the two species of gulls is presented in section 4.10.

On three occasions, the number of ducklings associated with a marked female increased after the first week of observation. This probably reflected the union of separate broods as for example in 1966 when the number of ducklings with a marked white-winged scoter increased from 8 to 13. The grouping of individual broods has been noted in many field-studies (Munro, 1941; Miller and Collins, 1954; Rienecker and Anderson, 1960).

The number of broods of marked females resighted, increased over the period of study from 31 to 50 per cent. Movements of broods may account for such a low proportion of resightings each season. A number of studies have shown that ducks with broods are capable of

travelling considerable distances from one water area to another (Evans *et al.*, 1952; Berg, 1956; Gates, 1962; Beard, 1964). Young (1967) found that mallard and black duck broods migrated overland from deep lakes to shallow bodies of water such as beaver ponds. Similarly, Heyland (in Young, 1967) noted that young flightless mallards had the ability to travel overland up to 3 1/2 miles in gentle terrain to reach other water areas, while Young (1967) found that some broods moved about a mile over extremely rough terrain. Therefore, the movement of some marked broods from Miquelon Lake to other water areas probably took place. I did occasional surveys of some of the ponds and marshes near Miquelon Lake but failed to locate marked broods on these areas. However, this did not exclude the possibility of broods moving out of the lake itself.

It has been well documented that duckling mortality is the highest during the first week after hatching (Low, 1945; Earl, 1950; Miller and Collins, 1954). Mendall (in Keith, 1961) maintains that the most crucial time for survival in ducklings is the first 48 hours after hatching. Keith (1961) found that 2/3 of the total loss of ducklings on his study area occurred during their first week of life. Assuming that duckling mortality is highest during the first week, a low mortality recorded at this time could result in high fledging success. On this basis it is possible that a high proportion of those

ducklings observed after one week fledged successfully, judging from the relatively low mortality during this period (Table 14).

Brood observations presented here are not indicative of the overall waterfowl situation at Miquelon Lake. Other broods were observed on the lake but only those initially marked on the islands were considered in the analyses.

4.9 Predation on Waterfowl Eggs

Predation was the most significant cause of egg losses during each of the three seasons of study (Table 8). With the exception of peninsula B, no evidence was found to indicate that mammals destroyed waterfowl eggs on the study areas. Coyotes (*Canis latrans*) were in abundance near the lake and moved easily over the land bridge to the B complex. Sooter (1946) maintains that eggs damaged by coyotes resemble closely those destroyed by avian predators. Coyote tracks were found near destroyed nests on peninsula B. Furthermore, Vermeer (1967) reported that coyotes destroyed many gull nests on B in 1965. Miller and Collins (1954) and Keith (1961) concluded that coyote predation did occur during their studies but at a low level. On the other hand, Bent (1907), Ferrel *et al.* (1953), and Harris (1954) labelled the coyote as one of the most notorious mammalian predators of waterfowl eggs on their study areas.

Nests initiated on islands A and C were subject only to avian predation. Magpies, crows, and gulls were the only apparent avian predators.

Some studies have shown that nests situated in excellent overhead cover suffer the most predation (Kalmbach, 1937) while others indicated the reverse (Kalmbach, 1938; Odin, 1957). Other investigators concluded that nests with poor overhead cover were pilfered by avian predators to the same extent as nests with excellent cover (Furniss, 1938; Hammond, 1940). There appears to be a lack of correlation between the degree of concealment and the susceptibility of waterfowl nests to avian predators. In order to ascertain the relationship of cover to nest predation on islands A and C, waterfowl nests in 1966 and 1967 were rated according to their visibility immediately overhead (Table 15). The cover preferences of the six waterfowl species studied are shown in Table 16.

Lesser scaup seemed to select nesting sites mainly in fair and good cover in both 1966 and 1967. Gadwalls, on the other hand, initiated the greatest proportion of nests in 1966 in excellent cover, and in 1967 fair cover. Kalmbach (1938) indicated that gadwalls tended to select nesting sites in areas of greatest cover. If the totals for this species are examined, the majority of nests were situated in areas having the highest cover value. Mallards tend to adjust to whatever cover is available (Girard, 1941).

Table 15. Cover at waterfowl nests rated on the basis of exposure from above.

Nest exposure	Cover value
very little or no overhead cover, nest completely visible	0 (Poor)
some overhead cover, nest relatively visible	1 (Fair)
abundant overhead cover, nest relatively invisible	2 (Good)
great abundance of overhead cover, nest completely invisible	3 (Excellent)

Table 16. Cover values at waterfowl nests initiated on islands A and C in 1966 and 1967.

Species		Cover value 0		1		2		3		Total	
		No. nests initiated	%	No. nests initiated	%	No. nests initiated	%	No. nests initiated	%	No. nests initiated	%
lesser scaup	1966	5	12.2	18	43.9	12	29.3	6	14.6	41	100.0
	1967	0	0.0	8	33.3	12	50.0	4	16.7	24	100.0
	Total	5	7.7	26	40.0	24	36.9	10	15.4	65	100.0
gadwall	1966	1	5.6	2	11.1	6	33.3	9	50.0	18	100.0
	1967	0	0.0	7	41.2	6	35.3	4	23.5	17	100.0
	Total	1	2.9	9	25.7	12	34.3	13	37.1	35	100.0
mallard	1966	1	20.0	3	60.0	1	20.0	0	0.0	5	100.0
	1967	0	0.0	4	57.1	2	28.6	1	14.3	7	100.0
	Total	1	8.3	7	58.4	3	25.0	1	8.3	12	100.0
pintail	1966	0	0.0	1	33.3	1	33.3	1	33.3	3	99.9
	1967	6	75.0	1	12.5	1	12.5	0	0.0	8	100.0
	Total	6	54.5	2	18.2	2	18.2	1	9.1	11	100.0
American widgeon	1966	1	50.0	0	0.0	0	0.0	1	50.0	2	100.0
	1967	0	0.0	0	0.0	0	0.0	1	100.0	1	100.0
	Total	1	33.3	0	0.0	0	0.0	2	66.7	3	100.0
white-winged scoter	1966	0	0.0	1	14.3	5	71.4	1	14.3	7	100.0
	1967	1	14.3	1	14.3	5	71.4	0	0.0	7	100.0
	Total	1	7.1	2	14.3	10	71.5	1	7.1	14	100.0
Subtotal	1966	8	10.5	25	32.9	25	32.9	18	23.7	76	100.0
	1967	7	10.9	21	32.9	26	40.6	10	15.6	64	100.0
Total		15	10.7	46	32.9	51	36.4	28	20.0	140	100.0

At Miquelon Lake mallards were one of the earliest nesting species. Only sparse, almost exclusively dry, vegetation was available at the time mallards commenced nesting. Therefore, the fact that the greatest proportion of nests were situated in lower cover ratings can be attributed to the quality of vegetation. The overall results for pintails show that they apparently prefer nesting sites in areas of lowest cover values. Pintails nesting in very sparse cover appears to be characteristic of this species (Bent, 1923; Munro, 1944; Rienecker and Anderson, 1960; Keith, 1961). The sample size for the American widgeon was insufficient to provide conclusive results on their cover preferences. Nests of the white-winged scoter were situated primarily in good cover.

The establishment of dummy nests in vegetation of varying cover values was undertaken to compare the susceptibility of these experimental nests and actual waterfowl nests to avian predators. Table 17 summarizes avian predation on naturally and artificially placed eggs under different cover ratings. In 1966 and 1967, no correlation existed between the degree of concealment and the amount of egg predation suffered by waterfowl. It appears that nests in lower cover ratings experience as much as or lower predation than nests situated in excellent cover. However, predation on dummy nests did appear to be a function of the degree of concealment. The amount of predation increased as cover values decreased.

Table 17. The extent of predation on naturally and artificially deposited clutches under varying cover values on islands A and C.

	Cover value					
	0			1		
Naturally deposited clutches (waterfowl nests)	No. nests initiated	No. clutches preyed upon	%	No. nests initiated	No. clutches preyed upon	%
1966	8	3	37.5	25	11	44.0
1967	7	0	0.0	21	7	33.3
Total	15	3	20.0	46	18	39.1
Artificially deposited clutches* (dummy nests)	No. nests maintained throughout experiment	No. clutches preyed upon	%	No. nests maintained throughout experiment	No. clutches preyed upon	%
1967	32	43	134.4	32	19	59.4

(continued)

Table 17. (continued)

	Cover value 2			Cover value 3		
Naturally deposited clutches (waterfowl nests)	No. nests initiated	No. clutches preyed upon	%	No. nests initiated	No. clutches preyed upon	%
1966	25	5	20.0	18	6	33.3
1967	26	6	23.1	10	1	10.0
Total	51	11	21.6	28	7	25.0
Artificially deposited clutches* (dummy nests)	No. nests maintained throughout experiment	No. clutches preyed upon	%	No. nests maintained throughout experiment	No. clutches preyed upon	%
1967	32	18	56.3	32	11	34.4

*domestic chicken eggs used--eggs were left covered by associated vegetation comparable to an actual waterfowl nest when the nesting female departs

Odin (1957) constructed dummy nests in cover of varying density and found that nests with least cover suffered the most from predators. These results were comparable to those he obtained for actual waterfowl nests. In the present study the lack of consistency in the rates of predation on waterfowl and dummy nests shows that dummy nests under cover of low value are more vulnerable to avian predators than waterfowl nests in equivalent cover. Possibly there are differences in the visibility of a waterfowl nest and a man-made nest in poor cover perceptible to the avian predator. Kalmbach (1937) indicated that ducks nesting in vegetation of low cover rating may defend their nests more zealously and remain at the nest site when danger threatens. Therefore, the lack of a female duck at dummy nests possibly contributed to the extremely high predation rate on these nests in poor cover as compared to waterfowl nests in similar cover.

From these data on nest predation it is evident that the amount of screening waterfowl nests possess has no bearing on their susceptibility to avian predators. Hammond and Forward (1956) suggested that avian predators may locate nests primarily by observing the approach and departure activities of nesting ducks. Since predation of actual waterfowl nests would then depend upon the activity of the nesting duck, the lack of any correlation between predation and cover rating follows. On

the other hand, when predators were not aided by the activities of a nesting duck but relied almost exclusively on their own keenness of sight to locate nests, a positive correlation between the amount of predation and the degree of overhead exposure in dummy nests would be expected.

Predators using look-out points to observe the activities of nesting waterfowl has been well established, especially for crows (Preston, 1957). On islands A and C in the present study, crows were frequently sighted perched on trees, but were observed in the act of raiding a waterfowl nest on only two occasions. Traps were set at some dummy nests in an attempt to determine if crows were the only nest predators. Table 18 summarizes the species and locations of birds trapped at dummy nest sites. In the majority of cases the captured predator had pecked open some eggs in the associated dummy nest.

The damage which crows and magpies inflict on the clutches of nesting waterfowl is well documented (Phillips, 1928; Hammond, 1940; Girard, 1941; Preston, 1957; Hanson and Browning, 1959; Lokemoen, 1967; Martz, 1967; and others). Ring-billed and California gulls similarly have been known to prey on waterfowl eggs (Miller and Collins, 1954; Odin, 1957; Hunt and Naylor, 1955; Keith, 1955; Gates, 1962). However, other investigators have concluded that waterfowl, nesting in the vicinity of gull colonies, were unaffected by gulls (Lewis, 1941; Gross, 1945; Behle and Goate, 1957). This disparity in results may be

Table 18. Birds captured at artificial nests in 1967.

Location	Birds captured			
	ring-billed gull	California gull	crow	magpie
Island A	0	3	2	4
Island C	4	3	0	0
Total	4	6	2	4

explained through variations in the behavior of gulls in different environments (Anderson, 1965). In this study gulls may have visited the dummy nests out of curiosity and were trapped after crows or magpies had already destroyed the nest and made good their escape. However, with the aid of a blind I was able to observe the destruction of three dummy nests by gulls, one by a ring-billed gull and two by California gulls. On the other hand, some experimental nests constructed within 1 foot of ring-billed and California gull nests were unharmed. Vermeer (1967) found that California gulls preyed upon duck eggs to a greater extent than ring-billed gulls. It is possible that only certain gulls will develop the habit of preying upon duck eggs, which Anderson (1965) suggests is a distinct possibility in the case of gulls preying upon ducklings.

It was not possible to determine which avian predator was responsible for the majority of nests destroyed on the study areas, since no predator left a characteristic sign with which it could be identified.

Gulls were the only predator trapped on island C, while gulls, crows and magpies were taken on island A. Captured gulls were color marked with spray paint and subsequently released; all crows and magpies were destroyed. No gull was captured more than once. Since only gulls were trapped on island C this could suggest that waterfowl nests lost on this island were preyed upon to

a greater extent by gulls than by any other avian species. Observations revealed that when crows visited island C they were largely ignored by gulls provided the crows remained near the shores of the island. If a crow flew over the interior of island C or over the gull colonies at low altitudes it was harassed and usually driven off by the gulls. This reaction on the part of gulls possibly protected nesting waterfowl from invading crows, however, some waterfowl nests eventually fell prey to the gulls themselves.

Another possibility which might account for the lack of crows and magpies taken on island C, is that the shores of this island were strewn with the carcasses of gull chicks that died from various causes (Vermeer, 1967). This ready carrion may have interested crows more than waterfowl eggs. They were frequently observed feeding on such carcasses along the shores of island C.

As there were no gulls nesting on island A in 1967 crows and magpies could move over the island unimpeded by gulls. Thus, the differences in the species of predator trapped on each island can probably be ascribed to the presence and absence of gulls on island C and A, respectively, and the fact that the carcasses of gull chicks on island C may have served as a more readily obtainable food source than waterfowl eggs.

Mammalian predation on waterfowl eggs has been shown to vary with time. Kalmbach (1938) found it to be highest

early in the season, while Sowls (1955) and Keith (1961) recorded the highest predation late in the nesting season. On study areas where the crow was the principal predator, many investigators have recorded a decline in predation during the latter part of the season (Phillips, 1928; Kalmbach, 1937; Hammond, 1940). Kalmbach (1937) attributes this to seasonal changes in the feeding habits of crows. He maintains that where duck eggs are relatively easy to obtain they become the preferred food item during the reproductive period of the crow. However, he states that duck eggs supply an insufficient volume of food for both nestlings and adults. Therefore, subsequent to fledging crows feed in other areas.

Table 19 summarizes the amount of predation on naturally and artificially placed nests with respect to the season at Miquelon Lake. The least predation on waterfowl nests occurred during the earliest and latest part of the season. The number of nests involved during these periods was low in relation to the more central periods. The low proportion of nests lost before May 22 and after July 26 may be associated with nest densities, which were below a threshold level sufficient to allow for effective predation. Data for the years 1965 and 1966 produced a statistically significant correlation between the number of nests existing at a particular time and the number of nests lost to predators. As the number of nests decreased the number of nests preyed upon

Table 19. Timing of seasonal predation on eggs in natural and artificial nests on islands A and C. Data on waterfowl nests include only those in which eggs either hatched or were destroyed by predators.

		Time of season									
		Before May 22		May 22-June 12		June 13-July 4		July 5-July 26		After July 26	
		Islands		Islands		Islands		Islands		Islands	
		A	C	A	C	A	C	A	C	A	C
no. nests existing											
waterfowl	1965	3	5	18	24	36	29	32	28	16	2
	1966	3	4	22	15	32	18	25	15	2	3
	1967	5	3	13	13	25	22	20	18	6	7
artificial	1967	-	-	16	16	16	16	16	16	-	-
no. nests lost to predators											
waterfowl	1965	0	2	5	9	8	5	9	13	2	0
	1966	0	0	3	5	8	3	5	1	0	0
	1967	0	0	3	0	2	5	2	1	0	1
artificial	1967	-	-	11	6	33	25	6	10	-	-
per cent nests lost to predators											
waterfowl	1965	0.0	40.0	27.8	37.5	22.2	17.2	21.9	46.4	12.5	0.0
	1966	0.0	0.0	13.6	33.3	25.0	16.7	20.0	6.7	0.0	0.0
	1967	0.0	0.0	23.1	0.0	8.0	22.7	10.0	5.6	0.0	14.3
artificial	1967	-	-	68.8	37.5	206.3	156.3	37.5	62.5	-	-

similarly decreased. Data for 1967 were not analyzed in this manner because of the assumed influence artificial nests may have had on predation.

There is a lack of consistency in the proportion of waterfowl nests lost during the season on islands A and C in any one year (1965 or 1966). Furthermore, there is no regularity in the proportion of nests lost on individual islands between the years 1965 and 1966. These variations in the amount of predation are probably the result of any one or a combination of factors, such as the species and number of predators involved, weather conditions, stage of reproductive cycle in the predator, the density of waterfowl nests, and other factors that were less obvious.

Through the period June 13 to July 14, 1967, predation on eggs in artificial nests was extremely high (Table 19). However, the loss of nests during the following period, July 5 to July 26, decreased by 168.8 per cent on island A and by 93.8 per cent on island C. The marked decline in predation between these two periods on island A may reflect the removal of two crows and one magpie during the period June 13 to July 4. After their destruction the rate of predation on island A decreased significantly. Three additional magpies were captured between July 5 and July 26. On island C such a marked decline in predation was not as apparent. These results strengthen the argument that crows and magpies were more active on island A than on C.

Hammond and Forward (1956) have considered the effect of humans on predation and noted that study techniques such as nest markers may furnish clues to predators as to the position of nests. Since nest markers were used, and since I did approach nests, my presence may have increased predation above that which would normally occur. However, complete elimination of the disadvantages accompanying the observer-approach method of performing nesting studies is practically impossible.

4.10 Predation on Waterfowl Broods

The impact of gulls on the survival of newly hatched ducklings as they attempted to leave the islands has been previously introduced (see section 4.8). Vermeer (1967) stated that many waterfowl broods were lost through the predatory activities of gulls in 1964. During the present study, 1965 through 1967, it is believed that gulls were the most significant predator on young ducklings, especially on island C where gull populations were substantially higher than those on island A.

It has been well documented that ducklings often fall prey to California gulls (Cottam, 1945; Greenhalgh, 1952; Odin, 1957; Keith, 1961; Anderson, 1965; Chura, 1965). Ring-billed gulls have been observed preying upon goslings (Munro, 1936) and young black-crowned night herons (*Nycticorax nicticorax*) (Wolford, 1966). However, Vermeer (1967) maintains that at Miquelon Lake ring-billed gulls

fed on ducklings to a lesser extent than California gulls. This he attributed to interspecific differences in size of gulls. The larger California gull, he states, fed on larger prey while the ring-billed gull concentrated more on smaller items such as mice and passerine birds.

In 1965 I did not observe any active predation on ducklings by gulls. In 1966 three waterfowl broods were observed entering the water from island C where they were soon preyed upon by California and ring-billed gulls. Similarly, in 1967 one brood was preyed upon by California gulls alone and two by both species. In every observation of active predation by gulls on waterfowl broods not one duckling managed to survive.

It became apparent to me, as to Vermeer (1967), that ducklings were not molested while on land, only on water. Vermeer (1967) suggested that the cryptic coloration of young ducklings may have protected them on land, whereas they became conspicuous on water. In order to clarify this I obtained four lesser scaup ducklings and released them on the sandy shore of island C where gulls congregated. Both species of gulls landed around the ducklings but paid little attention to them. In fact, the ducklings began moving along the shoreline and gulls made an effort to move out of their way. Obviously coloration was not the protective factor here. When I approached, the ducklings made their way toward water and began swimming away. Before, they managed to get 20 feet from the island

a California gull, observing them from the air, dove and captured one of the ducklings. This apparently stimulated other gulls flying nearby to attack and within a few minutes the remaining three ducklings were consumed. I have seen gulls actually plunge into the water after a duckling which was attempting to submerge.

It is apparent that the stimulus to attack ducklings is only received by gulls when ducklings are on water. Possibly the sight of a bobbing figure of specific body proportions breaking the water's surface initiates the attack.

I have observed in every instance when gulls preyed upon broods of waterfowl that a California gull was the first to attack. This could reflect a preference by ring-billed gulls for smaller food items which was overcome at the sight of California gulls attacking ducklings. On the other hand, ring-billed gulls may be dominated by California gulls. Vermeer's (1967) data on interspecific differences in the nesting habitat of these two species of gulls suggests such a relationship. He noted that ring-billed gulls usually retreated when confronted by a California gull. This subordinate attitude of ring-billed gulls may have prevented them from initiating the assault on newly hatched broods.

Observations on the speed and efficiency with which gulls destroy waterfowl broods suggests survival of ducklings associated with island C must have been very low.

4.11 Predation on Nesting Waterfowl

In 1965 four nesting females were found dead and partially eaten near their nests. Vermeer (1967) during the same year recorded seven gulls being killed in a similar manner. Feathers found near the carcasses of dead birds were identified as those of a great horned owl (*Bubo virginianus*). No further predation on nesting females or gulls was recorded in 1966 or 1967. In the spring of 1968 I visited island A and found a female mallard killed and eaten near her nest. The condition of the carcass suggested the same predator. Errington *et al.* (1940), Munro (1941), Evans *et al.* (1952), and Errington (1967) have recorded horned owl kills on their study areas. The appearance of the carcasses of birds found on the islands was practically identical to those pictured in Einarsen (1956).

4.12 Vegetation

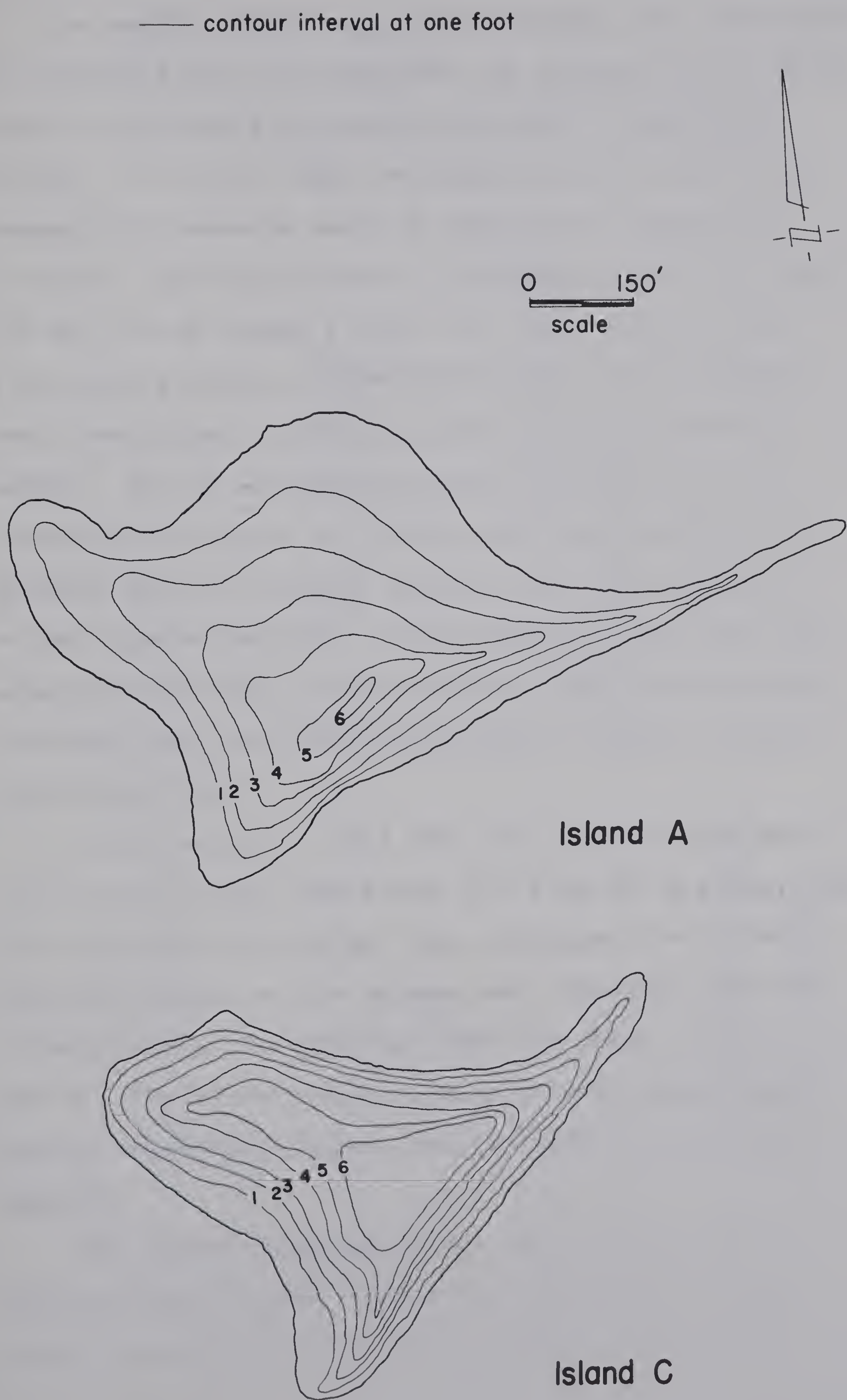
Waterfowl rely on vegetation as a source of food and nesting cover. Brock (1914) maintains that vegetation plays a major role in the distribution of birds. Knight (1965) observed that general changes in emergent and terrestrial vegetation in Montana, which increased the availability of food and cover, resulted in the area becoming more attractive to waterfowl. He recorded a substantial increase in the number and species of waterfowl nesting on the study area. On a Utah marsh, Weller *et al.*

(1958) obtained similar results for waterfowl. However, their data represented population trends in response to deterioration of the vegetation as a result of drought and over-grazing by cattle. Populations of nesting waterfowl dropped from a density of 6.6 nests per acre when vegetation was lush to 2.7 nests per acre subsequent to the degeneration of plant communities. It is evident that vegetation is a significant component in any waterfowl habitat. For this reason the present study examined the role of vegetation as an environmental factor in habitat selection. Herbicides were used to change floral components in order to investigate the influence of vegetation on the nesting of waterfowl.

Waterfowl nests were situated primarily among the following plant species: *Hordeum jubatum* and *Glyceria striata; Scirpus validus* and *S. americanus; Cirsium arvense;* and *Urtica gracilis*. Because these five genera were the most important, from the standpoint of nesting habitat, they will be the ones considered in my discussions.

Contour lines on islands A and C were mapped in 1965 (Fig. 14). Grasses, *Hordeum* and *Glyceria*, grew primarily along the perimeter of islands A and C, on the low shorelines (Figs. 2 and 3). *Scirpus* and *Cirsium* were found throughout, but only in localized areas did they attain high densities. Usually the higher interior portions of islands A and C supported the densest stands of *Urtica*.

Fig. 14. Contour intervals on islands A and C.


contour interval at one foot
0
150′
scale
1
2
3
4
5
6
Island A
1
2
3
4
5
6
Island C

On May 25, 1966, vegetation analyses were undertaken on islands A and C to determine the coverage of dry plant material available to nesting waterfowl in the early spring. In July of 1966 the application of herbicides caused the premature death of some of the vegetation in zones 1 and 2 on island A, and zones 2 and 3 of areas "X" and "Y" on island C (Fig. 4). On visiting island A during the winter of 1966-1967 it was quite apparent where herbicides had been applied during the previous summer. On the untreated portion of island A the dry skeletons of *Cirsium* and *Urtica* were considerably more abundant and of a greater density than those observed on the treated portion. It was suspected then that the amount of dry cover in the spring of 1967 would be considerably lower on the sprayed area of island A than on the control area.

In the spring of 1967 (May 25) analyses were again carried out on dry vegetation left from the previous year. The differences in the per cent coverage of dry plant material present on the sprayed and unsprayed zones of islands A and C for 1966 and 1967 are shown in Figs. 15 and 16. The herbicide 2,4-D affects only broad-leaved plants, therefore, *Circium* and *Urtica* were the target species.

The overall coverage of dry vegetation on the sprayed plots in 1967 dropped by 16 per cent in zone 1 and 17 per cent in zone 2 on island A from values

Fig. 15. Per cent coverage of dry vegetation on island A, May 25, 1966 and 1967. Zones 1 and 2 sprayed during July of 1966.

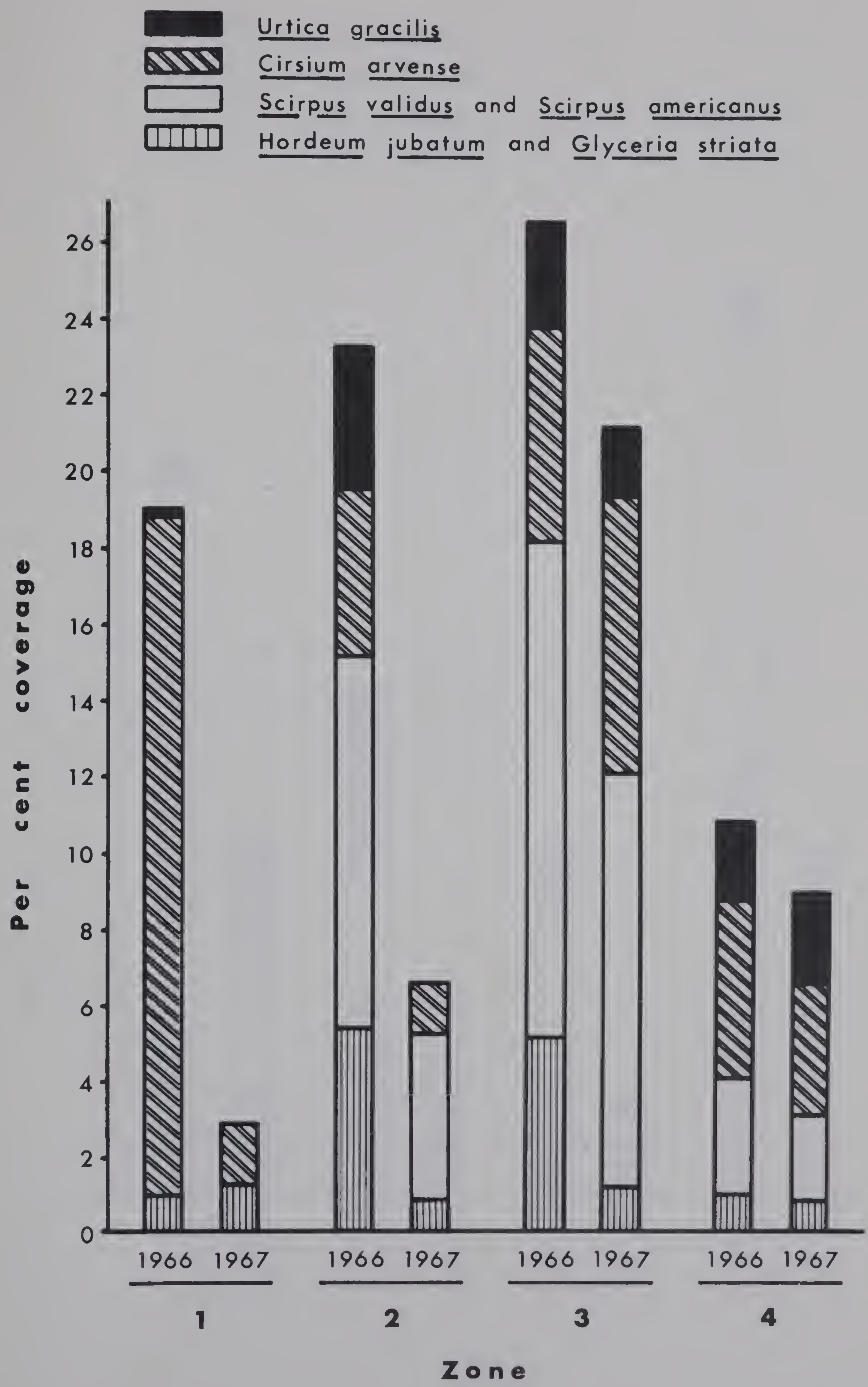
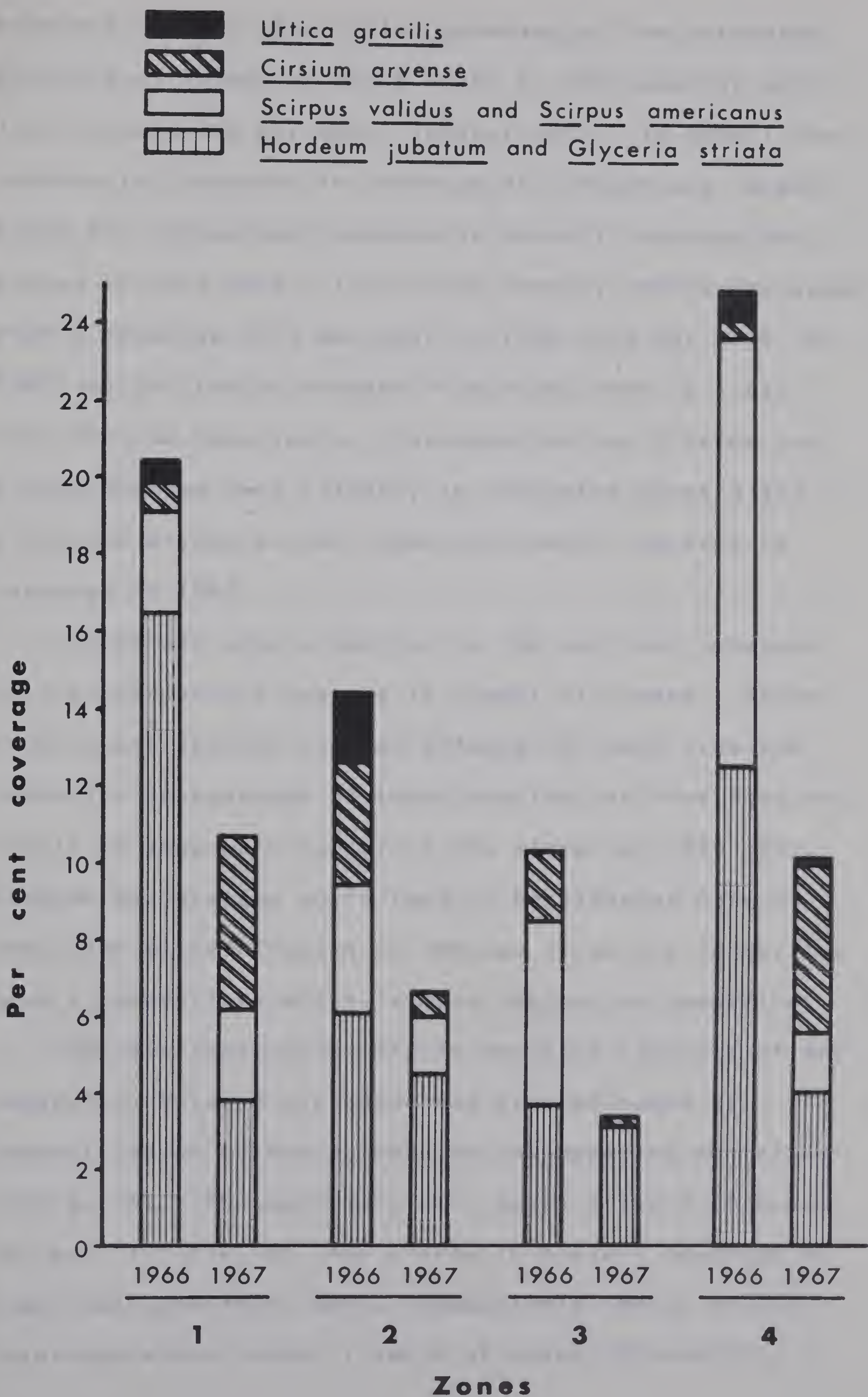

Urtica gracilis
Cirsium arvense
Scirpus validus and Scirpus americanus
Hordeum jubatum and Glyceria striata
Per cent coverage
0
2
4
6
8
10
12
14
16
18
20
22
24
26
1966 1967
1966 1967
1966 1967
1966 1967
1
2
3
4
Zone

Fig. 16. Per cent coverage of dry vegetation on island C, May 25, 1966 and 1967. Zones 2 and 3 sprayed during July of 1966.



Urtica gracilis
Cirsium arvense
Scirpus validus and Scirpus americanus
Hordeum jubatum and Glyceria striata
24
22
20
18
16
14
12
10
8
6
4
2
0
Per cent coverage
1966 1967
1966 1967
1966 1967
1966 1967
1
2
3
4
Zones

recorded in 1966 (Fig. 15). Coverage on the untreated portions of island A, zones 3 and 4, decreased by only 7 per cent and 2 per cent, respectively. In zone 1 the substantial decrease in coverage of *Cirsium* was responsible for the marked reduction in overall coverage observed in this zone. In treated zone 2, *Urtica* decreased from a coverage of 4 per cent in 1966 to 0 per cent in 1967, while *Cirsium* dropped from 4 per cent to 1 per cent for the same years. Coverage for dry *Cirsium* and *Urtica* changed only slightly in untreated zones 3 and 4 for the 2-year period, showing a small increase in coverage in 1967.

There was also a decline in the per cent coverage of dry *Scirpus* and grasses in almost all zones. Since these plant species are not affected by herbicide the reduction in coverage of these species may have been the result of snow-packing during the winter of 1966-1967. *Scirpus* and grasses would tend to be affected more by snow than either *Cirsium* or *Urtica*, since the former two have a growth form which is more subject to compaction.

The distinct variations in per cent coverage of dry vegetation between untreated and treated zones as exemplified on island A, were not as apparent on island C (Fig. 16). The sprayed plots, zones 2 and 3 of areas "X" and "Y" (Fig. 4), had a drop in overall coverage of 8 per cent and 7 per cent, respectively, while on the unsprayed plots, zones 1 and 4 of areas "X" and "Y", a

decrease in coverage of 10 per cent and 14 per cent was recorded, respectively (Fig. 16). It is apparent that on the untreated zones more of a decrease in overall coverage was recorded than on the treated portions of island C. However, if individual plant species are considered coverage of broad-leaved plants in the sprayed portions, zones* 2 and 3, declined by 4 and 2 per cent, respectively, whereas in the untreated zones 1 and 4, broad-leaved plants increased by 3 and 3 per cent, respectively.

The rather significant decline in coverage of *Scirpus* and grasses reflects the presence of gulls and their trampling of dry vegetation during the establishment and maintenance of the colonies. In the spring of 1966 I noticed dry beds of *Scirpus* in some zones to be relatively tall and offering considerable nesting cover. However, in the spring of 1967 these same patches of *Scirpus* were flattened almost to ground level, offering practically no cover. The same may be said for grasses in some areas of island C.

The first vegetation analyses on new growth was carried out on June 15 in 1966 and 1967. Three additional analyses were run at regular intervals up to August 14 in both years. A comparison of the per cent coverage was then made between years for zones that received no

*zones--when used in association with island C implies zones that are in both areas "X" and "Y".

herbicidal spray in either 1966 or 1967, zones treated in either 1966 or 1967 but not both years, and zones sprayed in 1966 and 1967.

Islands A, zone 4, and C, zones 1, were not subjected to herbicide treatment. Fig. 17 depicts the growth pattern of new vegetation in these zones for 1966 and 1967. There was a general increase in coverage in the majority of plant species throughout the summer of each year. A slight decrease was noted in coverage of grasses on island C in 1966 and *Urtica* in 1967. In general, the first two samples in 1966 on both islands resulted in a higher overall coverage than the corresponding samples in 1967, probably because of the late spring in 1967. However, samples 3 and 4 in 1967, on islands A and C, produced a greater overall coverage than was recorded during the same period in 1966.

Zone 1 on island A, and zones 2 on island C were sprayed between the taking of samples 2 and 3 in 1966 (Fig. 18). During 1967 these zones were not sprayed with herbicide. Coverage of *Cirsium* and *Urtica* increased to the time of spraying in 1966 on both islands, but subsequent to the application of herbicides, coverage for these species decreased noticeably. However, in 1967, when these zones were not treated, a continuous increase in coverage was recorded for *Cirsium* on both islands. *Urtica*, on the other hand, decreased on island C. It is obvious that in the year following the use of

Fig. 17. Chronological increase in vegetative cover in zones of islands A and C that were not subjected to herbicide treatment in 1966 or 1967.

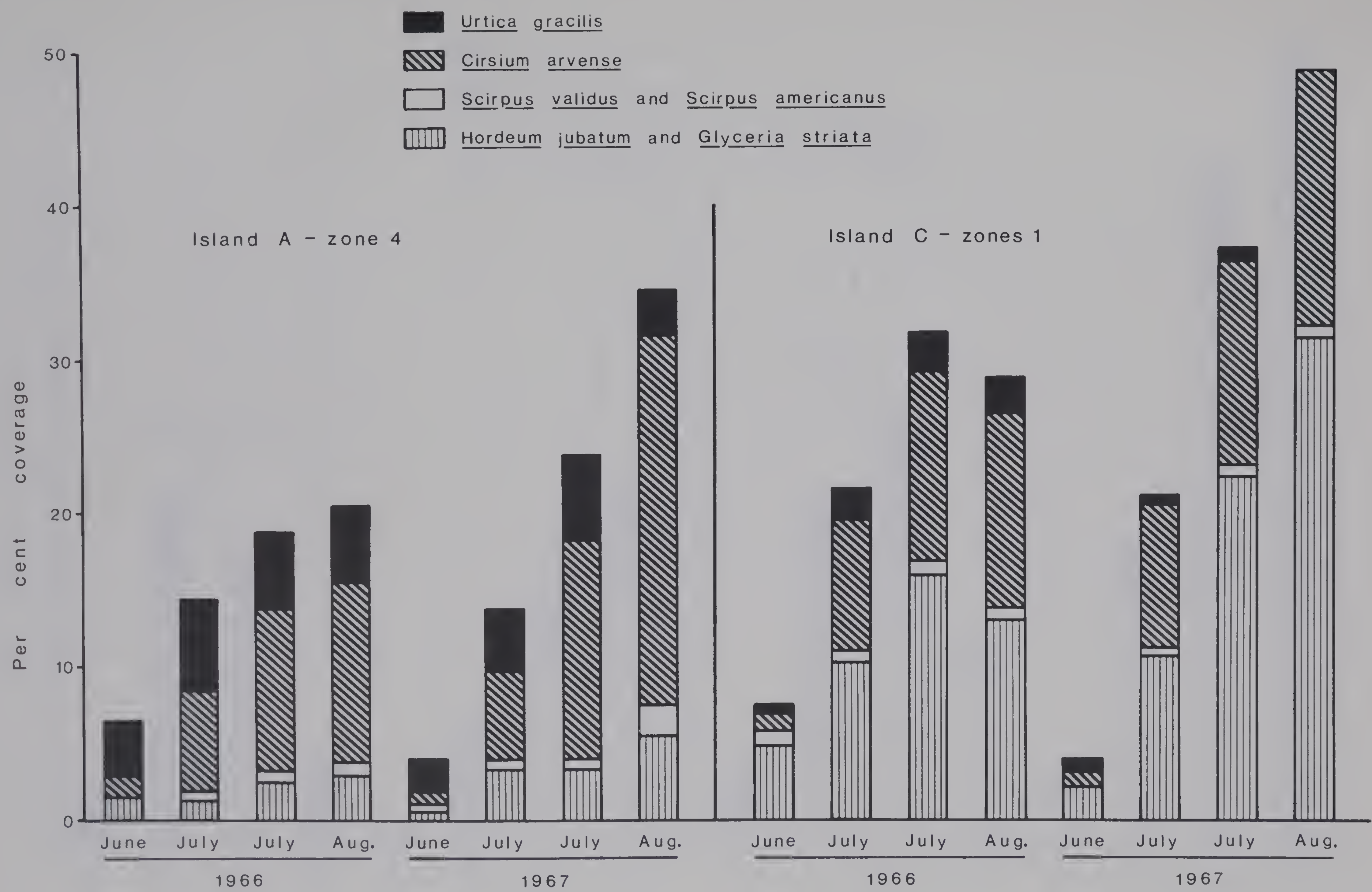
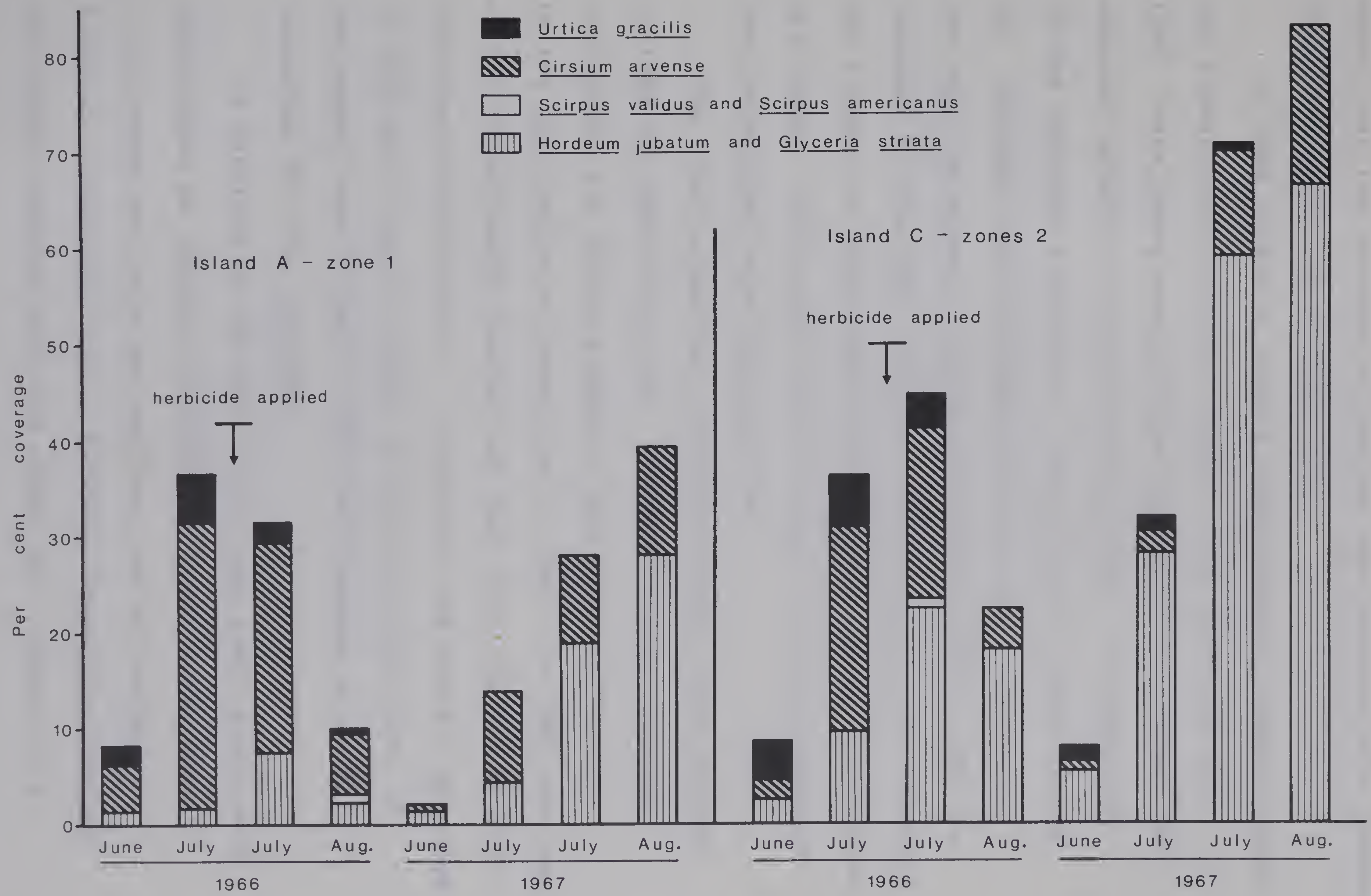

Urtica gracilis
Cirsium arvense
Scirpus validus and Scirpus americanus
Hordeum jubatum and Glyceria striata
Island A - zone 4
Island C - zones 1
Per cent coverage
0
10
20
30
40
50
June
July
July
Aug.
June
July
July
Aug.
1966
1967
June
July
July
Aug.
June
July
July
Aug.
1966
1967

Fig. 18. Chronological increase in vegetative cover in zones of islands A and C that were treated once with herbicide in 1966 but not in 1967.



Urtica gracilis
Cirsium arvense
Scirpus validus and Scirpus americanus
Hordeum jubatum and Glyceria striata
Island A - zone 1
Island C - zones 2
herbicide applied
herbicide applied
Per cent coverage
0
10
20
30
40
50
60
70
80
June
July
July
Aug.
June
July
July
Aug.
1966
1967
June
July
July
Aug.
June
July
July
Aug.
1966
1967

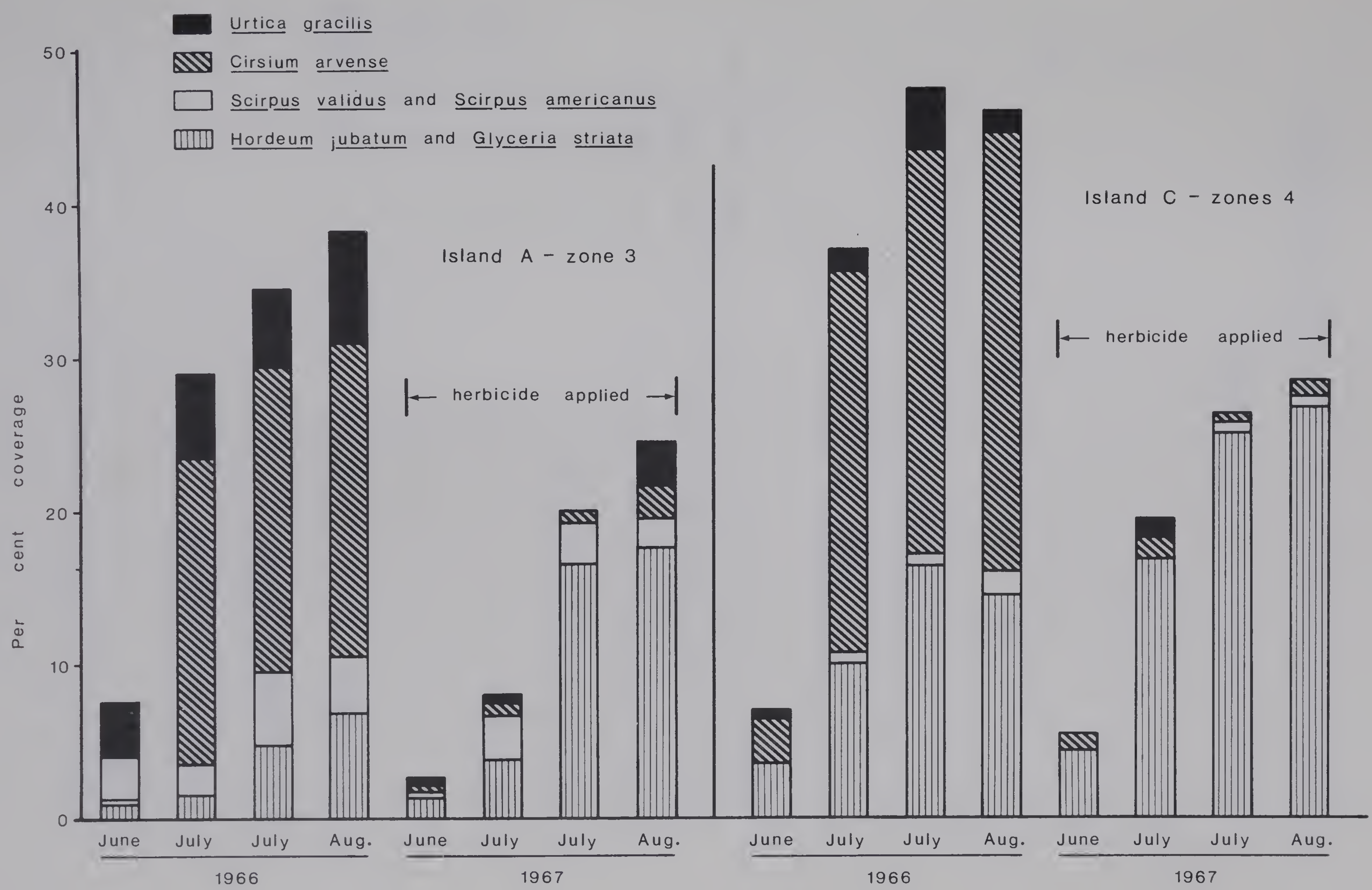
herbicides the coverage of grasses was substantially greater than that noted the previous year.

In 1966 island A, zone 3, and island C, zones 4, were not treated with chemical sprays. The following year, 1967, these zones were sprayed repeatedly to prevent the abundant growth of broad-leaved species. A comparison of the coverage analyses on these plots is shown in Fig. 19. The most striking observation on both islands was the very low overall coverage on these plots in 1967 as compared to the 1966 analyses. These results are obvously the outcome of herbicides reducing the coverage of *Cirsium* and *Urtica*. Here again grasses appear to have increased when herbicides were being applied.

The final comparison was made between zones sprayed in 1966 and 1967 (Fig. 20). On both islands coverage of *Cirsium* and *Urtica* gradually decreased subsequent to the application of herbicide in 1966. In 1967 coverage of the broad-leaved species was kept very low and grasses increased significantly. In general, the overall coverage in 1967 was slightly higher during the latter part of the season than it was in 1966, but grasses primarily accounted for this increase.

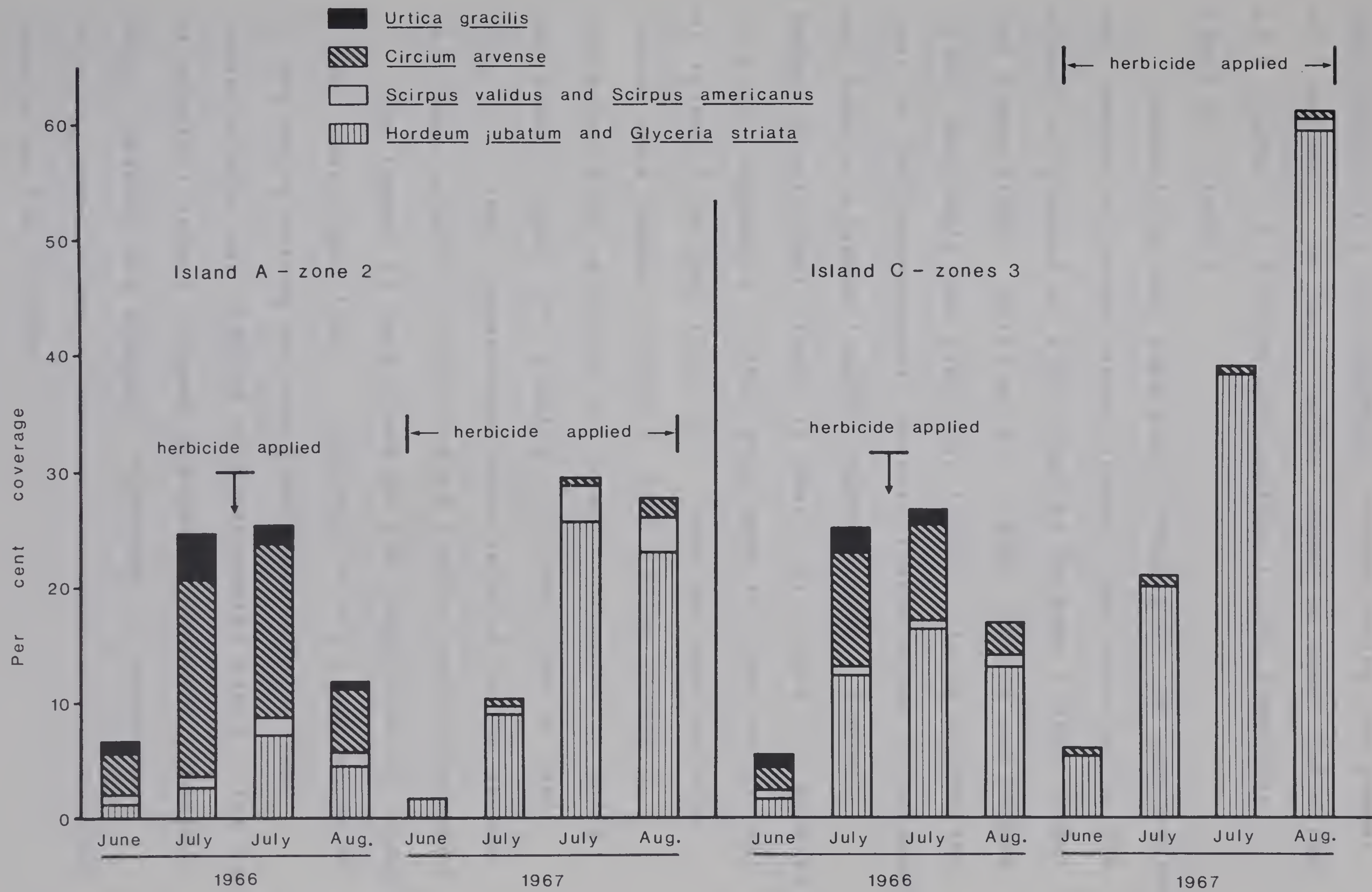
In addition to the main plots, two small plots were established on island A in 1966. On one Tordon 22K at 1 1/2 ounces per acre was applied, and on the other 2,4-D at 1 pound per acre. Periodic inspection through the summer revealed that the effect of 1 pound 2,4-D

Fig. 19. Chronological increase in vegetative cover in zones of islands A and C that were not treated with herbicide in 1966 but were treated weekly in 1967.



Urtica gracilis
Cirsium arvense
Scirpus validus and Scirpus americanus
Hordeum jubatum and Glyceria striata
Per cent coverage
0
10
20
30
40
50
Island A - zone 3
herbicide applied
Island C - zones 4
herbicide applied
June
July
July
Aug.
June
July
July
Aug.
1966
1967
June
July
July
Aug.
June
July
July
Aug.
1966
1967

Fig. 20. Chronological increase in vegetative cover in zones of islands A and C that were treated with herbicide in both 1966 and 1967.


Urtica gracilis
Circium arvense
Scirpus validus and Scirpus americanus
Hordeum jubatum and Glyceria striata
Island A - zone 2
Island C - zones 3
herbicide applied
herbicide applied
herbicide applied
herbicide applied
Per cent coverage
0
10
20
30
40
50
60
June July July Aug. June July July Aug.
1966
1967
June July July Aug. June July July Aug.
1966
1967

was matched by 1 1/2 ounces of Tordon during the summer of treatment. In fact, Tordon seemed to equal the effect of 2 pounds 2,4-D which was applied to the remaining plots on island A.

Competition was apparently reduced by the suppression and removal of broad-leaved plants, thus encouraging the growth of grasses as also noted by Hartman (1956), Hyder and Sneva (1956), Keith *et al.* (1959), Burton and Hughes (1961) and Cable and Tschirley (1961). It is noteworthy that in 1967 two annuals, mustard (*Descurainea richardsonii*) and Russian pigweed (*Axyris amaranthoides*), suddenly became significant plants in zone 1 of island A. Because of their abundance in 1967 they were included on the map of island A in 1967 (Fig. 2). These two species also became more common in zone 1, area "Y" on island C, untreated with herbicide but heavily trampled by gulls and zone 2, area "X", treated with herbicide in 1966 (Fig. 3). Their appearance seems related to the vacuum left when perennial broad-leaved species were eliminated.

The impact of herbicides on the vegetation of islands A and C was significant. Coverage of dry plant material in the early spring and new growth of certain broad-leaved plants was reduced on experimental plots. The use of chemical sprays allowed grasses to increase. Annual herbs, mustard and pigweed, increased in response to thinning and killing of some of the other dicotyledonous species on the islands.

4.13 Vegetation and Waterfowl

Hochbaum (1944) found that nesting waterfowl tolerate the close proximity of one another regardless of species. In each of the three years of study at Miquelon Lake the positions of all waterfowl nests were plotted on maps of islands A and C (Figs. 21 and 22). Distances were measured between all nests and the nearest neighboring waterfowl nest. Fig. 23 depicts the pattern of nest dispersion as represented by the distribution of distances between waterfowl nests located on islands A and C for the three seasons. Accompanying each figure is a distribution curve of distances which would be expected if waterfowl nests were spaced entirely at random (see Appendix 2).

The yearly variation in the distribution of nest distances from one another was tested by the method outlined by Clark and Evans (1954). It was found that the distributions did not differ significantly from year to year on each island. However, calculations revealed that the distribution of distances in each year on each island deviated significantly from randomness in the direction of aggregated spacing. Since some waterfowl species showed a definite preference for specific types of nesting cover, the clumping of nests on each island was probably in response to the distribution of vegetation. Table 20 summarizes the placement

Fig. 21. Distribution of waterfowl nests and gull colonies on island A from 1965 through 1967.

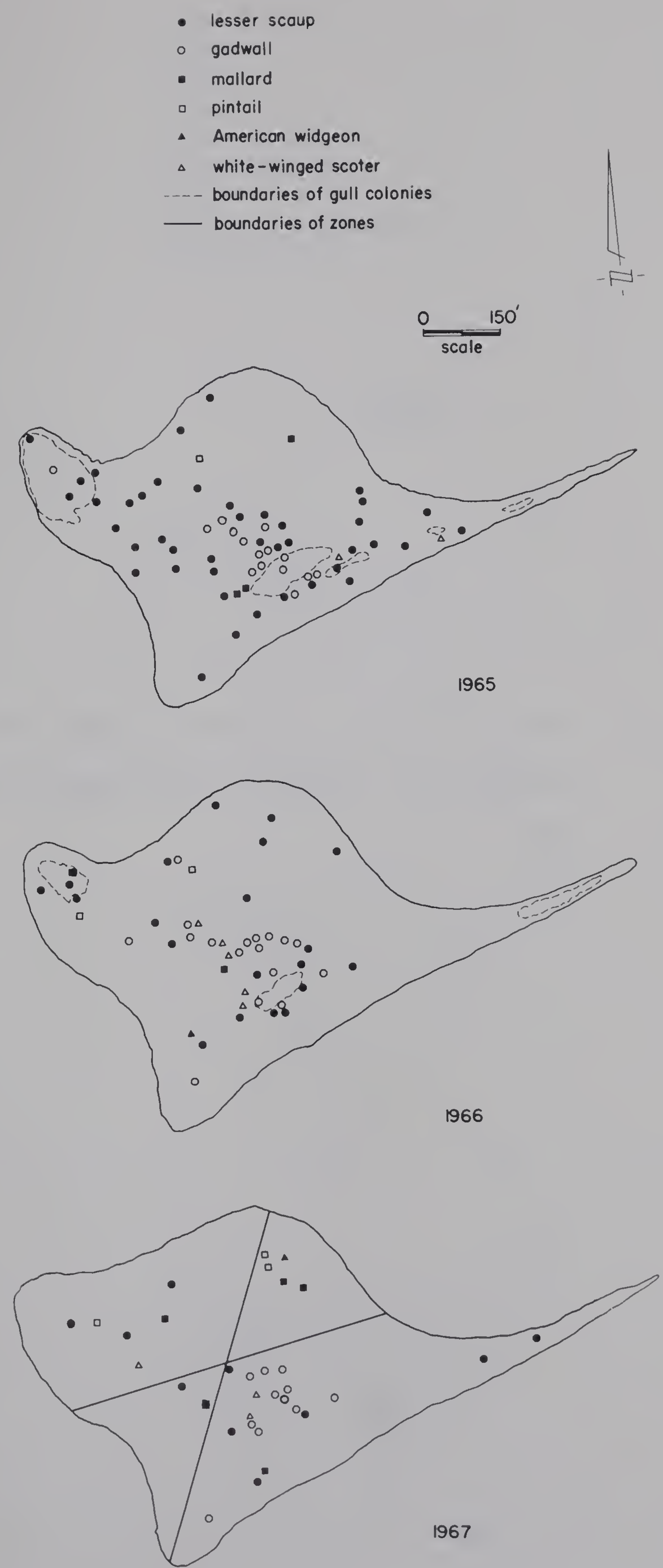

lesser scaup
gadwall
mallard
pintail
American widgeon
white-winged scoter
boundaries of gull colonies
boundaries of zones
0 150′
scale
1965
1966
1967

Fig. 22. Distribution of waterfowl nests and gull colonies on island C from 1965 through 1967.

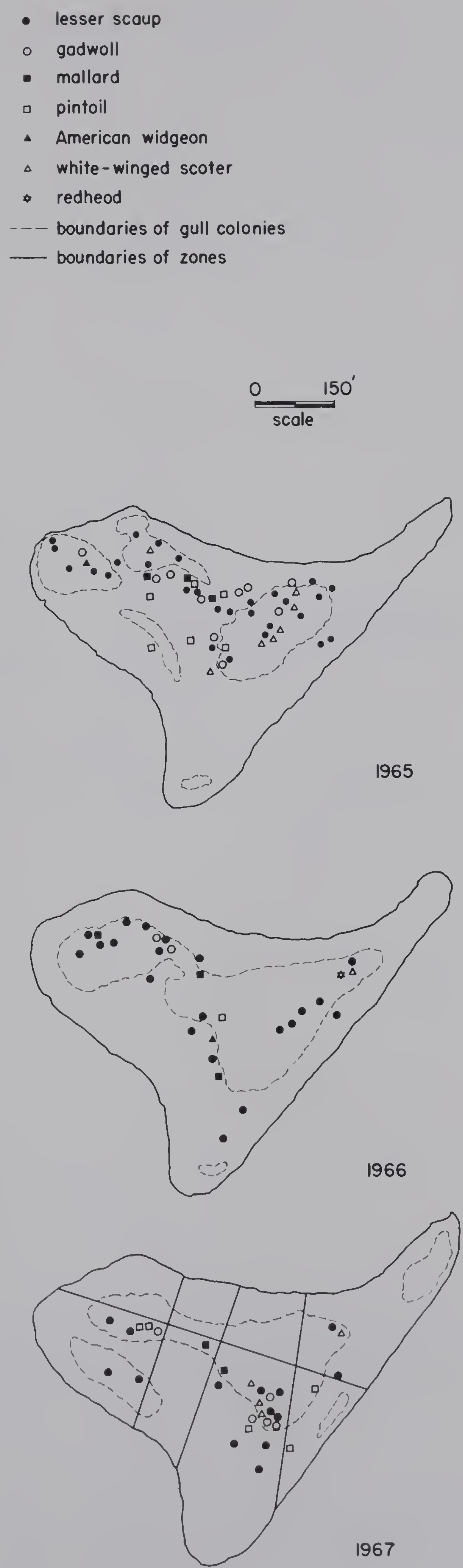
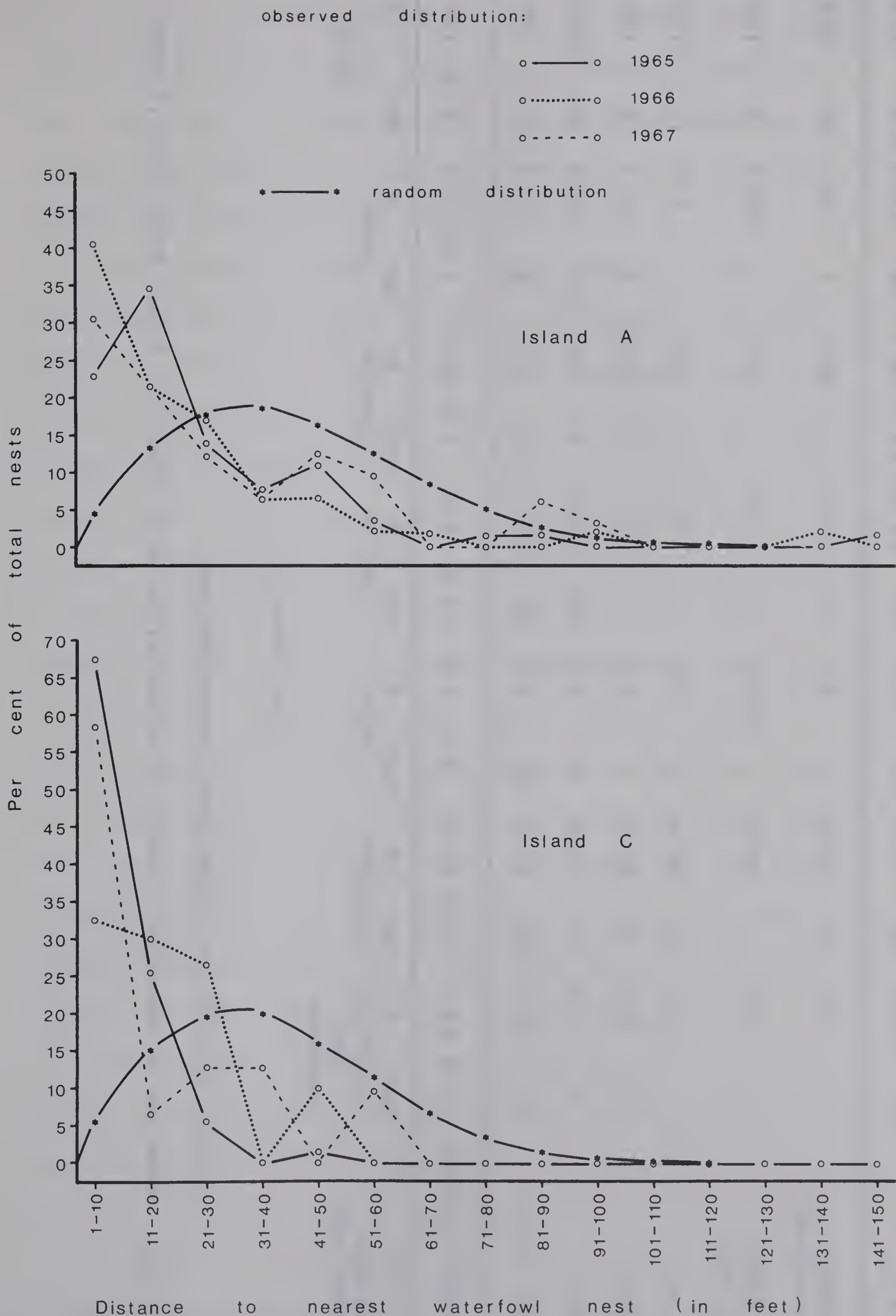

lesser scaup
gadwoll
mallard
pintoil
American widgeon
white-winged scoter
redheod
boundaries of gull colonies
boundaries of zones
0
150'
scale
1965
1966
1967

Fig. 23. Distribution of distances between waterfowl nests on islands A and C from 1965 through 1967.



observed distribution:
1965
1966
1967
random distribution
Island A
Island C
Per cent of total nests
Distance to nearest waterfowl nest (in feet)
1–10
11–20
21–30
31–40
41–50
51–60
61–70
71–80
81–90
91–100
101–110
111–120
121–130
131–140
141–150

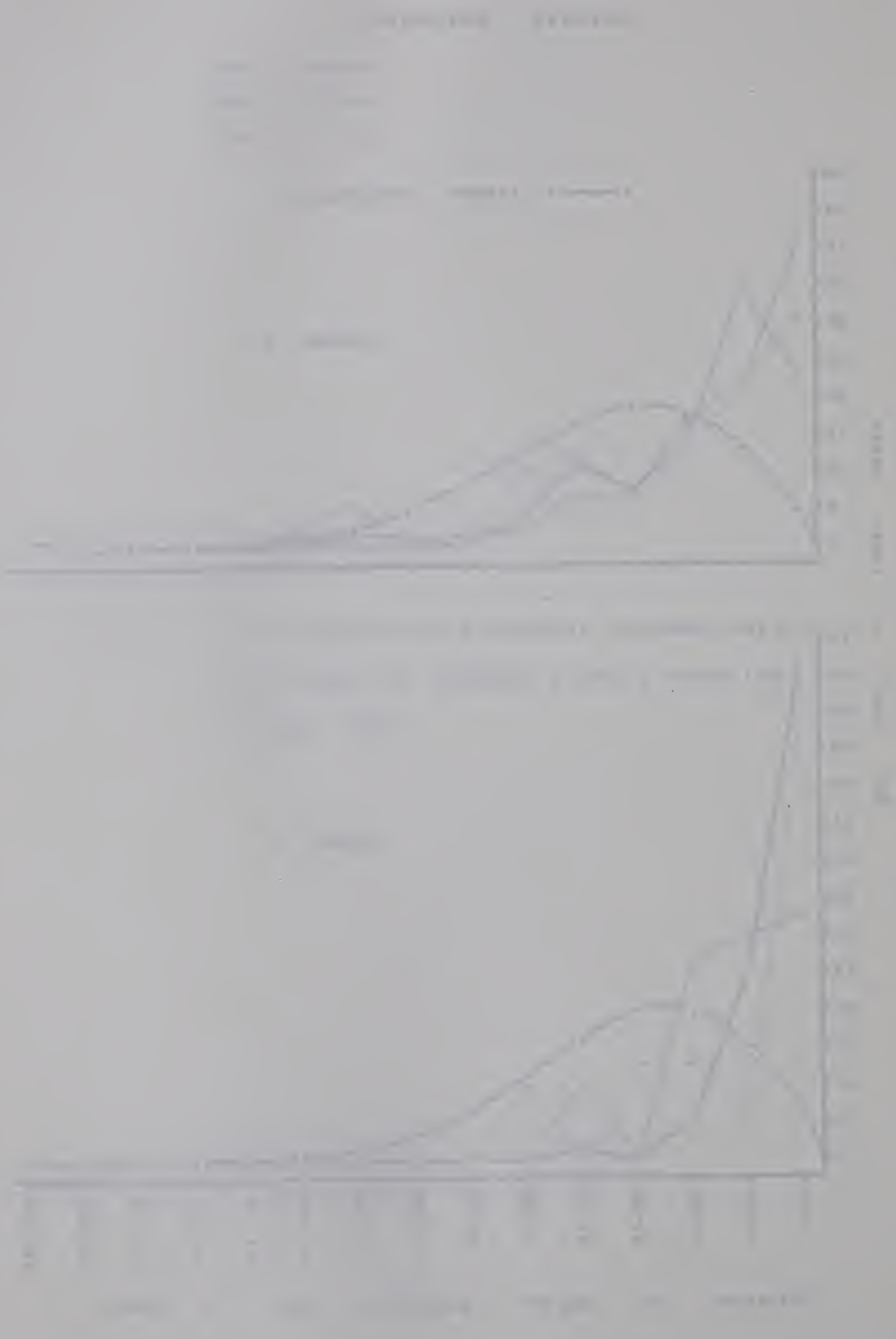


Table 20. Location of waterfowl nests in association with specific plant genera on islands A and C during the three-year investigation.

Acreage and species	Plant genera												Total	
	Hordeum and *Glyceria*		*Scirpus*		*Carex*		*Urtica*		*Cirsium*		Other			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
average acreage	2.5	43.1	0.6	10.3	0.1	1.8	0.4	6.9	1.2	20.7	1.0	17.2	5.8	100.0
lesser scaup	22	16.3	18	13.3	26	19.3	28	20.7	23	17.1	18	13.3	135	100.0
gadwall	0	0.0	3	5.0	2	3.3	35	58.3	8	13.4	12	20.0	60	100.0
mallard	0	0.0	8	44.4	1	5.6	2	11.1	5	27.8	2	11.1	18	100.0
pintail	3	16.7	8	44.4	0	0.0	0	0.0	6	33.3	1	5.6	18	100.0
American widgeon	0	0.0	1	20.0	1	20.0	0	0.0	2	40.0	1	20.0	5	100.0
white-winged scoter	2	9.1	0	0.0	2	9.1	6	27.3	10	45.4	2	9.1	22	100.0
Total	27	10.5	38	14.7	32	12.4	71	27.5	54	20.9	36	14.0	258	100.0

of waterfowl nests in association with certain plant genera. The availability of each cover type is also presented. Data for years and islands were combined to increase sample sizes and give a more representative picture of vegetation preferences of waterfowl.

Lesser scaup appeared to select *Carex* and *Urtica* more than any other type of cover. Gadwalls showed a distinct preference for *Urtica* patches as 58.3 per cent of the nests located during the study were established in this cover. *Urtica* consisted of an average of only 6.9 per cent of the available nesting cover for each season. The selection of *Urtica* as a prime nesting site by gadwall is well known (Miller and Collins, 1954; Hammond and Mann, 1956; Duebbert, 1966). Mallards tended to nest in dry *Scirpus* and *Cirsium*. These two plant species afforded the most cover during the early part of the nesting season. Pintails also selected nesting sites that were essentially in dry *Scirpus* and *Cirsium*. Dry vegetation of the previous year is of great importance to early nesting waterfowl. Keith (1961) found that 85 per cent of cover for pintails and mallards consisted of old growth. White-winged scoters seemed to select nesting sites primarily in *Urtica* and *Cirsium* stands. The sample size of five nests for the American widgeon was insufficient to exhibit any definite preferences.

In general, when comparing the relative importance of each type of vegetation, the broad-leaved species,

Urtica and *Cirsium*, and *Carex* were the preferred sites for nesting. A total of 48 per cent of all waterfowl nests were located in *Urtica* and *Cirsium*, with the remaining 52 per cent situated in the other four plant categories. The grasses, *Hordeum* and *Glyceria*, although constituting 43.1 per cent of the available cover did not appear to be favored by nesting waterfowl. Duebbert (1966) found that 80 per cent of all waterfowl nests were in association with *Urtica* and *Cirsium*. Miller and Collins (1954) concluded that nettles served as the most important nesting cover for waterfowl.

The fact that certain plant species were preferred by waterfowl as nesting sites would lead to the aggregated spacing of waterfowl nests seen on islands A and C.

The spraying of herbicides on islands A and C was undertaken in mid July, 1966. In order to determine what impact this had on nesting populations in 1967, the total numbers of nests in one of the untreated and treated zones during 1965, 1966, and 1967 was tabulated (Table 21). Also included are the numbers of nests that would be expected in these areas if the changes in numbers were proportional to changes in the total nesting population.

On island A, in 1966, the expected number of nests slightly exceeded the observed number in both treated and untreated zones. In 1967, the year following treatment,

Table 21. Changes in the numbers of nests initiated by all species of waterfowl in control and experimental zones during the period 1965 to 1967 on islands A and C.

Year	Untreated 1966* Islands A no. nests observed	expected†	C no. nests observed	expected	Treated 1966** Islands A no. nests observed	expected	C no. nests observed	expected	Total no. observed nests Islands A	C
1965	41	-	22	-	6	-	12	-	63	55
1966	25	30	15	12	3	5	5	7	47	30
1967	20	18	25	16	2	2	0	5	33	31

*zone 4 island A and zones 1 island C
**zone 1 island A and zones 2 island C treated with herbicides in mid July, 1966, subsequent to nest initiation by waterfowl
†see Appendix 4 for methods used in calculating expected values

only a small difference resulted between observed and expected numbers in the untreated zone, while the observed and expected were equal in the treated zone. When considering the numbers of nests that were expected and those observed, spraying on island A in 1966 was apparently of little significance to nesting waterfowl. This may be attributed to the fact that relatively few waterfowl nested in zone 1, the sprayed area, as compared to zones 2 and 4 where the majority of each year's waterfowl population nested. If a greater number of nests had been situated in zone 1 during the first two years of study a more significant effect of spraying might have been observed in 1967.

On island C, 1966, the observed number of nests was comparable to what was expected in the untreated and treated zones. However, in 1967, zones treated in 1966 had no nests although 5 were expected on the basis of the overall change in total numbers of nesting waterfowl. The untreated zones had 25 nests and only 16 were expected. This suggests that in 1967, waterfowl were selecting nesting sites in zones that were not subjected to herbicide the previous year. In zones treated in 1966 there was a decrease in broad-leaved cover in 1967 and a significant increase in grasses (Fig. 18). The apparent movement of nesting birds into the control zones on island C in 1967 may have been accelerated by the spraying that was undertaken in 1967.

In order to ascertain the effect of the spray program in 1967 comparisons of the numbers of nests observed and expected were made between zones treated in 1967, those treated in 1966, and control zones (Table 22). As herbicide was applied 1-2 times a week from early June to mid August, 1967, this probably affected those species of waterfowl that rely heavily on green broad-leaved vegetation as nesting cover (i.e. late nesting species).

On island A the effect of treating zones 2 and 3 in 1967 was to reduce the observed number of nests below that which was expected and raise the observed number in control zone 4 above the expected value. In zone 1, which was not treated in 1967 but subjected to herbicide in 1966, the observed number of nests was comparable to the expected number. An explanation why this zone did not have more nests than expected when zones 2 and 3 were being treated is the fact that broad-leaved cover decreased in zone 1 in 1967 as compared to 1966, while grasses increased during the same period of time (Fig. 18). Therefore, zone 1 probably was less attractive to nesting birds.

On island C the effect of repeated spraying in 1967 was more evident. Treating zones 3 and 4 resulted in a decline in the number of nests below the expected, while in control zones 1, more nests were observed than expected. In zones 2, which were treated in 1966, no

Table 22. Changes in the numbers of nests initiated by late nesting species of waterfowl (i.e. excluding mallards and pintails) in various control and experimental zones from 1965 to 1967 on islands A and C.

Year	Island A				Island C			
	Zone 1*		Zone 4**		Zones 2*		Zones 1**	
	no. nests				no. nests			
	observed	expected††	observed	expected	observed	expected	observed	expected
1965	6	-	39	-	10	-	19	-
1966	3	4	24	28	5	6	12	11
1967	1	2	19	14	0	5	21	11

(continued)

Table 22. (continued)

Year	Island A Zones 2† and 3†		Island C Zones 3† and 4†		Total no. observed nests Islands	
	no. nests					
	observed	expected	observed	expected	A	C
1965	14	-	17	-	59	46
1966	16	10	9	10	43	26
1967	5	9	3	8	25	24

*treated with herbicide in mid July, 1966, subsequent to nest initiation by waterfowl
**not treated with herbicide in any year
†treated with herbicide repeatedly from early June to mid August, 1967
††see Appendix 4 for methods used in calculating expected values

nests were observed in 1967 while 5 were expected. This apparent avoidance of zones 2 by nesting waterfowl in 1967 may be the result of a carry-over effect herbicides had in 1966. Less broad-leaved cover and more grasses were recorded in these zones in 1967 as compared to 1966 (Fig. 18). In each of the zones on island C the observed and expected values were comparable in 1966. However, subsequent to herbicide treatment in 1966 and 1967 waterfowl may have been forced to nest in the control zones which were never subjected to herbicide and where broad-leaved cover continued to grow relatively undisturbed.

Sample sizes in these data presented in Tables 21 and 22 are low and it may not be possible to derive solid conclusions. However, one favorable observation is that wherever spraying was undertaken the observed number of nests in 1967 were lower than expected except in one instance where they were comparable on island A (Table 21). In zones untreated, the observed number of nests in 1967 were consistently greater than expected. These data suggest that vegetative cover provided by broad-leaved species was an important factor influencing the distribution of waterfowl nests on the islands.

The acreage covered by five major groups of plants on islands A and C was determined in 1965, 1966, and 1967. The density of waterfowl nests located in each type of vegetation during the study is presented in Table 23. When examining the overall densities of nests in the five

Table 23. Density of waterfowl nests on islands A and C from 1965 through 1967.

Species of vegetation	Density (nests per acre)					
	1965 Islands		1966 Islands		1967 Islands	
	A	C	A	C	A	C
Hordeum jubatum and *Glyceria striata*	4.5	2.8	1.3	0.8	1.2	0.9
Scirpus validus and *S. americanus*	20.0	30.0	4.5	20.0	6.7	20.0
Cirsium arvense	10.0	22.5	2.7	6.7	2.9	10.0
Urtica gracilis	23.0	50.0	26.7	20.0	27.5	66.7
Carex rostrata	30.0	50.0	50.0	30.0	0.0	60.0
Total	12.1	10.1	7.8	5.2	4.4	5.8

plant groups each year, it can be seen that they follow the general trend set by the total numbers of waterfowl nests initiated on individual islands during the investigation (Table 1). The small increase in density on island C in 1967 (from 5.2 to 5.8), although not significant, may reflect changes in the composition of plant communities through the use of herbicides. In that year the repeated application of herbicidal spray to zones 3 and 4 decreased the amount of available broad-leaved cover. With this decrease in nesting cover waterfowl were forced to nest either in cover that was not directly affected by the herbicide, namely grass-like species, or in vegetation in the control zones. As it was necessary to keep the comparisons between years comparable on a density-per-vegetation-type basis, densities of nests in grass-like species were calculated on the basis of the entire island in 1967, whereas densities for *Cirsium* and *Urtica* were calculated only in zones where these species were unaffected by chemical, zones 1 and 2 of areas "X" and "Y". In *Cirsium* the density of waterfowl nests increased slightly in 1967. This may reflect the movement of nesting females into the control zones where suitable cover was more available (Tables 21 and 22). Significantly greater densities were recorded in *Carex*. With the overall reduction in broad-leaved cover on the island more use was made of *Carex* by lesser scaup in particular. The acreage of *Carex* remained relatively constant between the years 1966 and

1967. The coverage afforded by *Urtica* on island C in 1967 was extremely low in untreated zones (Figs. 17 and 18). Therefore, the significant increase in nest densities in this species of cover follows.

The density of waterfowl nests in individual plant groups ranged from a low of 0.8 nests per acre in *Hordeum* and *Glyceria* to a high of 66.7 nests per acre in *Urtica*.

From these data it is apparent that vegetation was a very important ecological factor in determining nest distribution on the islands.

4.14 Impact of Herbicides

The control of plant communities has been recognised as an important means of managing wildlife (Goodrum and Reid, 1956). Herbicides have been introduced as one method of manipulating the floral component of the environment to achieve this end. Goodrum and Reid (1956) state, however, that there is a danger that the undesirable plant species for which herbicides were originally developed may be essential for wildlife food and cover in certain areas. This is why the indiscriminate use of chemical sprays is an increasing threat to wildlife interests (Yocum, 1954).

The herbicide used on the islands of Miquelon Lake in 1966 and 1967, 2,4-D (2,4 - dichlorophenoxyacetic acid), is a synthetic plant hormone or auxin (Fogg, 1963). This type of weed killer affects broad-leaved plants by dis-

turbing the growth processes of the plant until death eventually ensues (Hartman, 1956).

Various workers have investigated the direct effects of herbicides on wildlife and concluded that the toxicity of most herbicides to warm-blooded animals is almost negligible (Rowe and Hymas, 1954; Rudd, 1954; Cowan, 1955; George, 1960). In fact Mitchell *et al.* (1946) fed domestic cattle and sheep 2,4-D mixed in with normal food rations at a rate of 5.5 grams per day for 106 days and recorded no harmful effects. Rudd (1954), Cowan (1955), and George (1960) maintain that the more important effects of herbicides are felt indirectly by natural populations of animals through the modification of the flora in a given habitat. Some investigators have concluded that following the use of chemical sprays the habitat, improved by changes in vegetation, became more suitable for resident wildlife (Steenis, 1956; Chamberlain and Goodrich, 1962; Martin, 1966; Mueggler, 1967). On the other hand, Keith *et al.* (1959) reported that by spraying 2,4-D on weedy rangeland in Colorado, the habitat became less attractive to pocket gophers (*Thomomys talpoides*). He recorded an 87 per cent decrease in the pocket gopher population the year following treatment. Therefore, herbicides can either increase or decrease the worth of an area to wildlife indirectly through changing the composition of plant communities.

Considering waterfowl specifically, the needs of

ducks are met by available cover types to varying degrees. This is evident when examining the vegetation preferences of different waterfowl species. Williams and Marshall (1938) stated that by controlling the species, quantity, and distribution of vegetation, the number and species of nesting waterfowl in a particular habitat may be influenced. They concluded, for example, that the gadwall population in the Bear River Refuge would be reduced if weeds were destroyed. Near Tacoma, Washington, much agricultural land has been allowed to grow up to grasses and weeds in order to provide nesting habitat for waterfowl (Swanson and Jeffrey, 1965).

Vegetative cover on the islands of Miquelon Lake is of considerable importance in the distribution of waterfowl nests. The direct effects of 2,4-D application were seen in the increase in grasses and the marked decrease in nesting cover provided by nettles and thistles, both in the early spring when dry vegetation served as the most available cover for nesting waterfowl, and during the summer when new growth is most important. Accurate data on the indirect effects of 2,4-D on waterfowl populations, through modifications in plant communities, can only be ascertained by extended studies on plant succession and subsequent changes in the number and species of waterfowl nesting on the islands as opposed to the general population characteristics of the area. However, with the data available it is possible to speculate on the

outcome of a continued use of herbicides on the islands. Eradication of the two most important broad-leaved species, nettles and thistles, and an expansion of the grass community would be the most obvious initial result. The reaction of waterfowl to these rapid alterations in the environment are difficult to say. However, at the species or individual level one or both of the following may occur: 1) those species of waterfowl that rely heavily on broad-leaved plants for nesting cover, gadwalls, lesser scaup, and white-winged scoters, would decrease in numbers on the islands. Perhaps lesser scaup would not be as greatly affected since they prefer grasses to a greater extent than any other species and may remain on the islands in relatively high humbers. 2) The various species of waterfowl nesting on the islands may switch their vegetation preferences and use the dominant cover type available after spraying, causing no significant change in waterfowl populations. There was some indication that waterfowl may have moved into the unsprayed areas of island C where broad-leaved plants continued to provide ample nesting cover (section 4.13). Since there was still some preferred cover remaining on the island waterfowl continued to nest. However, if these broad-leaved species were completely removed, waterfowl may be discouraged from nesting there.

4.15 Habitat Selection

The physical ability of birds to disperse is relatively unrestricted because of their powers of flight. Yet practically all birds possess a definite breeding range, which is manifested by selection of a specific habitat. The mechanisms by which one habitat is selected are not known. However, Miller (1942) and Svärdson (1949) suggest that the selection of a specific habitat probably involves receptivity of the bird to a complex of environmental stimili. Hilden (1964, 1965) has postulated that stimuli are received by a bird in two orders of magnitude. The ultimate factors in a given environment provide the stronger stimuli, whereas proximate factors provide stimuli at a lower level of magnitude. He states that ultimate environmental factors are such things as availability and quality of food, environmental requirements imposed by the anatomical characteristics of the species, and the availability of shelter from enemies and adverse weather. Proximate variables include sites for nesting, singing, observing, feeding and drinking, and the presence of other animals. If the summation of positive environmental stimuli exceeds a threshold level, the selective response is elicited (Miller, 1942; Hilden, 1965).

Some of the possible reasons why the study areas in Miquelon Lake were attractive to nesting waterfowl are: 1) their insular position; 2) vegetation on them;

3) associated gull colonies on them.

Hammond and Mann (1956) have concluded from studies conducted in the Lower Souris Refuge that the island habitat holds a high attraction for nesting waterfowl primarily because: 1) it is relatively free from mammalian and avian predators; 2) it is in close proximity to water, food, loafing and look-out sites, and nesting cover; 3) there is a greater opportunity for the establishment of territories because of the high shore to land mass ratio. Hilden (1965) also indicated that islands are preferred by waterfowl because islands lack mammalian predators. Assuming that these criteria are valid, islands in Miquelon Lake possess the more important ultimate factors--an accessible nesting ground, availability of food and protection from mammalian predators--and a number of proximate variables--availability of water, loafing and look-out sites, and nesting cover. Hammond and Mann (1956) suggested that in many water areas where waterfowl production was low, productivity could be increased if islands were constructed. They also concluded that vegetative cover was of secondary importance to island-nesting ducks. At Miquelon Lake as well, the fact that the study areas were encompassed by water seemed the principle factor attracting waterfowl. This was illustrated rather well in 1966. Off the western tip of peninusla B (Fig. 1) in 1966 was a small island not considered in the study. Its size was approximately 30 to 40

feet across the widest point. Six lesser scaup nests were located on this small island. Nesting cover consisted of only short grass. On the larger peninsula B, considerably more nesting cover was available but only 4 lesser scaup nests were initiated there. A definite selection for the island habitat seemed evident.

It has been suggested that a social bond developes between some species of waterfowl and gulls so that waterfowl tend to select nesting sites in the vicinity of gull colonies (Hilden, 1964, 1965). Under these circumstances gulls ward off avian predators that pose a threat to the colony and indirectly protect nesting waterfowl.

Bergman (in Hilden, 1964) is of the opinion that the phenomenon of waterfowl being attracted to gulls is learned. Koskimies (in Hilden, 1964) suggests that this trait is passed on to succeeding generations of waterfowl through the process of imprinting on ducklings. In view of the numbers of gulls and the amount of calling they do, such a process seems feasible (Fabricius, in Nice, 1953). Therefore, it is probable that ducklings hatched on islands in association with gulls become imprinted. Any ducklings that survive may return to nest on the islands in subsequent years, partly in response to gull colonies.

The attraction of gulls for waterfowl, if such a relationship did exist on the study areas, could have manifested itself through attracting waterfowl to the islands per se or attracting waterfowl to the gulls

thereby influencing the placement of their nests. To investigate these possibilities the distances between all waterfowl nests and the nearest gull nest were recorded. Table 24 summarizes the distances between nests of waterfowl and gulls on islands A and C. Figs. 21 and 22 show the placement of waterfowl nests in relation to the distribution of gull colonies on these islands.

An increase in abundance of nesting waterfowl has been recorded when the size of the gull colony increased (Hilden, 1964). In 1966 the gull population on island C increased significantly and remained at this level in 1967. However, the number of waterfowl nests declined abruptly in 1966, then leveled off in 1967. On island A the decrease in waterfowl populations coincided with the general decline in gull numbers from 1965 through 1967. However, the decline in gull populations on island A each year were far from being comparable to the substantial increase recorded in 1966 on island C. Therefore, it is improbable that the loss of gulls on island A was directly related to the decline in numbers of nesting waterfowl. In summary, there is no evidence that abundance of waterfowl nests was correlated with that of gulls.

If gull colonies affected the placement of waterfowl nests directly, then the distance between the nests of waterfowl and gulls would remain relatively constant regardless of the density of gulls. On island A the numbers of gulls decreased from approximately 300 to 60

Table 24. Spatial relationship between nesting waterfowl and gulls on islands A and C from 1965 through 1967.

Year	No. waterfowl nests		Approx. no. gulls		Distance in feet from waterfowl nest to nearest gull nest			
	Islands		Islands		Islands			
	A	C	A	C	A		C	
					Mean	Range	Mean	Range
1965	63	55	300	900	85	2-225	34	1-110
1966	47	30	60	2000	102	12-200	18	1-180
1967	33	31	0	2000	-	-	20	3- 75

individuals in 1966. However, the mean distance to the nearest gull nest increased from 85 to 102 feet. On island C the increase in number of gulls produced a decrease in mean distance, which would be expected on a restricted area such as an island. Therefore, the nearness of a waterfowl nest to a gull nest was not determined by the gull colonies themselves. The more significant factor contributing to the distribution of nests on the islands was vegetation (see section 4.13).

In summary, the insular position of the nesting grounds at Miquelon Lake was the main feature attracting waterfowl to the area. Once the islands were selected, vegetation governed the placement of their nests. Imprinting of ducklings on gull colonies may have caused some waterfowl to return to the islands. However, if the colonies did exert any influence on waterfowl populations as a whole, it was not as significant as the role played by insular position and vegetation. There was no evidence to suggest that waterfowl nests were situated near gull nests as a result of an attraction toward gulls.

Vermeer (1967) concluded that virtually none of the ducklings hatched in 1964 on the islands survived because of heavy gull predation. These islands have existed for 18 years and it is possible that a heavy loss of ducklings may have persisted since this interspecific association began. In spite of this, waterfowl have continued to nest on the islands. If very low productivity

was a yearly occurrence this situation is remarkably similar to that of the velvet scoter (*Melanitta fusca*) nesting in the archipelago of southern Finland (Koskimies, in Errington, 1967). Koskimies noted that young scoters suffered high mortality. Predators and unfavorable weather reduced survival to virtually zero during the most severe seasons. Populations associated with the archipelago were maintained only through immigration of ducks produced elsewhere. Errington (1967) indicated that this "biological luxury" does not require any survival value as long as an excess of waterfowl is produced in other areas. Such a situation may have existed at Miquelon Lake. If so, the islands were, in effect, an "ecological trap" for waterfowl, that is, the populations of waterfowl utilizing the islands were maintained by immigration of birds from outside areas.

Data compiled in 1965 and 1966 concerning brood success (sections 4.8 and 4.10) suggested that during these years net productivity on the islands was low. However, I do not think it was at such an extremely low level that nesting populations in succeeding years had to rely entirely on immigrant waterfowl. In 1967, productivity on island C was probably low again. However, with the lack of gulls on island A, the success of ducklings associated with this island is believed to have been relatively high. With the increased success of ducklings in 1967 on island A, the dependance on immigrant waterfowl

to make-up nesting populations on the islands, if such was the case in preceeding years, would be decreased considerably in future years until productivity is again reduced by exceedingly high mortality in ducklings.

5. CONCLUDING DISCUSSION

The insular position of the study areas in Miquelon Lake seemed to be the major factor drawing nesting waterfowl to them. The lack of mammalian predators and the absence of grazing cattle probably were responsible for selection of the relatively isolated islands by many nesting ducks. Flora on the islands was of considerable importance in determining the placement of nests. However, I believe this factor was of lesser importance as an attractive force to the islands themselves. Data on cover preferences of the various species of waterfowl and experiments on vegetation manipulation, substantiate the role of vegetation as a factor influencing the distribution of nests on the islands. I am confident that the impact of gull colonies on habitat selection by waterfowl was negligible, either as an attractive or a repulsive force.

Data gathered on productivity of waterfowl on the islands have shown major losses to the population at two stages in their life history--eggs and young ducklings. Avian predators, namely crows, magpies, and gulls, affected to a great extent the proportion of eggs hatching on the islands each year. However, the species which destroyed the most eggs was not determined. Desertion of nests by female waterfowl as a result of banding activities was highest in 1965; as techniques were improved nest losses due to this cause

were reduced. To what extent my presence on the islands may have assisted avian predators in locating waterfowl nests is not known. Nest markers may have aided in the discovery of nests by furnishing unusual objects to attract the attention of predators. However, as markers were at a considerable distance from any nest and not of sufficient height to be good look-out points, it is doubtful that they contributed significantly to nest losses.

The amount of nesting cover, provided by varying densities of vegetation, was not correlated with the extent of predation and consequently was discarded by the author as a protective factor against avian predators.

Predation on newly hatched ducklings associated with the gull-free island was believed considerably lower than around island C where gulls were more numerous. Confirmation would require a concentrated study of the food habits of gulls nesting on the islands. Furthermore, a means of tracking broods subsequent to their departure from the islands would be essential to determine success.

I believe productivity of waterfowl on the islands of Miquelon Lake could be increased significantly by a few relatively minor adjustments to the nesting habitat. First, if trees on the islands were removed this would eliminate perching sites for crows and magpies. With the opportunity to observe nesting waterfowl reduced considerably, nest predation by these two avian species would probably decrease significantly, therefore, increasing the

proportion of nests hatching. Gulls pose another problem to nesting waterfowl and their broods. Vermeer (1967) states that gulls display an avoidance for dense herbaceous or shrub cover. In order to make the area less attractive to gulls it would be possible to artificially introduce more shrubs to the islands. The plant species that would be the most acceptable is wild gooseberry (*Ribes oxyacanthoides*). This plant is easily obtainable as it is very common on peninsula B and around the lake in general. Waterfowl would not be discouraged from nesting on the islands if this particular species were in great abundance, judging from the relatively few *Ribes* shrubs that were on the islands and the extent to which they were utilized by nesting waterfowl. Anderson (1965) has similarly suggested the introduction of plant cover to discourage nesting gulls and to make an area more attractive to nesting waterfowl. With the reduction in gull populations, nesting success and brood success would undoubtedly increase. A final recommendation to increase waterfowl productivity on the islands is to encourage the growth of tall broad-leaved plants. As these species of plants are favored highly by nesting ducks, their abundance would increase the value of the islands as a nesting habitat for waterfowl.

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APPENDIX 1

Precipitation and temperatures recorded during the summers of 1966 and 1967 on island A in Miquelon Lake, Alberta.

Date		Ppt. (inches)		°F Max.		°F Min.	
		1966	1967	1966	1967	1966	1967
May	4	-	-	-	46	-	20
	5	-	-	-	50	-	28
	6	-	-	-	44	-	38
	7	-	-	-	45	-	33
	8	-	-	-	43	-	35
	9	-	-	-	41	-	26
	10	-	-	-	41	-	20
	11	-	-	-	45	-	28
	12	-	-	-	45	-	22
	13	-	-	-	52	-	32
	14	-	-	-	54	-	32
	15	-	-	-	38	-	38
	16	-	-	-	60	-	30
	17	-	-	-	58	-	28
	18	-	-	-	59	-	31
	19	-	-	-	60	-	30
	20	trace	-	-	68	-	34
	21	0.19	trace	-	68	-	38
	22	trace	trace	-	66	-	43
	23	0	0	-	58	-	42
	24	0	0.50	-	54	-	44
	25	0	1.00	75	49	45	39
	26	0	0	81	60	49	40
	27	0	0	64	64	58	46
	28	0	0	76	67	41	44
	29	0.16	trace	84	61	52	42
	30	0.22	trace	64	58	48	38
	31	0.13	trace	67	59	45	40
June	1	0.05	0	59	55	41	47
	2	0.10	0.20	65	72	43	48
	3	trace	0.14	64	46	43	42
	4	trace	0	60	53	46	32
	5	trace	0	56	50	40	33
	6	0	0	57	60	37	42
	7	0	0.01	62	69	37	46
	8	0	0	64	60	41	40
	9	0	0.50	71	47	45	37
	10	0.31	0.40	57	43	44	34
	11	0.13	0.20	56	44	40	36

(continued)

Appendix 1 (continued)

Date		Ppt. (inches)		°F			
				Max.		Min.	
		1966	1967	1966	1967	1966	1967
June	12	0	0	62	58	43	35
	13	0	0.04	72	61	42	38
	14	0.10	0.07	66	60	49	42
	15	0	0	74	60	47	43
	16	0	0.48	80	47	45	46
	17	0	0.26	80	52	51	48
	18	trace	0.02	82	58	52	45
	19	trace	0	76	61	49	44
	20	0.05	trace	75	67	46	45
	21	0	0	74	62	45	40
	22	0	0	76	48	54	39
	23	0	0	76	52	43	40
	24	0	0	65	65	43	46
	25	0.08	0	69	70	50	48
	26	0	0	74	73	48	54
	27	0.03	trace	74	63	52	59
	28	trace	0	75	66	51	52
	29	0	0	73	60	47	54
	30	0.37	0.07	74	58	46	44
July	1	0.10	0	72	59	43	46
	2	0.26	0	67	62	44	48
	3	0.14	trace	66	60	43	46
	4	0.10	0	68	63	45	47
	5	0	0	73	61	54	48
	6	0	0.14	76	60	52	50
	7	0.51	0	83	61	59	46
	8	0	0	75	64	55	52
	9	0	0	79	63	57	48
	10	0.02	0	72	65	56	50
	11	0	0	73	70	50	52
	12	trace	0	70	61	49	51
	13	trace	0	69	64	56	50
	14	0	0	83	68	57	53
	15	0	0	84	72	58	54
	16	0	0	80	78	58	53
	17	0	0	75	67	59	52
	18	0	0.22	82	72	58	57
	19	0	trace	82	61	56	51
	20	trace	0.13	62	68	40	53
	21	trace	0.56	60	52	42	50
	22	trace	0.13	70	63	49	51
	23	0	0.20	72	64	48	53
	24	0.45	0.06	62	60	48	50

(continued)

Appendix 1 (continued)

Date		Ppt. (inches)		°F			
				Max.		Min.	
		1966	1967	1966	1967	1966	1967
July	25	0.53	0	60	65	47	49
	26	0.10	trace	64	67	46	52
	27	0	0	72	66	48	59
	28	0.03	0.05	79	69	56	52
	29	trace	0	68	69	56	54
	30	trace	0	79	64	48	50
	31	0.20	0.15	72	56	42	48
August	1	0	0.03	80	61	52	49
	2	0	0.02	82	55	48	49
	3	0.65	0	72	74	56	52
	4	0.22	0.11	68	73	55	53
	5	1.10	0	65	58	53	53
	6	0.24	0	67	54	53	49
	7	0	1.00	68	50	51	43
	8	0	0	70	62	49	48
	9	trace	0	72	68	52	57
	10	0.32	0	68	72	42	55
	11	0.21	0	65	73	43	53
	12	trace	0	64	70	41	52
	13	trace	0.10	60	72	49	50
	14	0	0	68	68	49	55
	15	0.16	0	72	70	50	58

APPENDIX 2.

Calculation of the random distribution curve for nearest neighbor distances of waterfowl nests on islands A and C in Miquelon Lake, Alberta. (see Fig. 23)

The formula:

$$N(\chi) = n\left\{\exp.[(-\pi n/\underline{A})(\chi-1/2a)^2]-\exp.[(-\pi n/\underline{A})(\chi+1/2a)^2]\right\}$$

where: N = Number of waterfowl nests on a specific island.

$\underline{A}$ = Area with nests; mean area of island A during the three years was 329,604 square feet, and for island C 226,512 square feet.

n = Number of waterfowl nests in area $\underline{A}$; mean number of nests on island A for the three years was 48, and on island C 39.

a = Unit of measurement used for measuring distances between waterfowl nests; the distances of all nests were grouped 1-10 feet, 11-20 feet, 21-30 feet, etc., the mid point of each group was selected, 5.5 feet, 15.5 feet, 25.5 feet, etc.; therefore, the unit of measurement was 10 feet.

χ = Distance to the nearest neighboring nest, which was 5.5 feet, 15.5 feet, 25.5 feet. ......145.5 feet.

exp.= Exponential = 2.7183

For example, to calculate the number of waterfowl nests which would be 5.5 feet from the nearest neighbor on island A, if nests were distributed entirely at random, the formula reads:

$$N(5.5) = 48\left\{\exp.[(-22/7\cdot 48/329604)(5.5-1/2\cdot 10)^2]-\exp.[(-22/7\cdot 48/329604)(5.5+1/2\cdot 10)^2]\right\}$$

N(5.5) = 2.2 waterfowl nests

All calculations were made on APL* computer system.

*A Programing Language

APPENDIX 3.

Formulae used to calculate data presented in Table 5.

A.) Total no. banded ♀♀ on islands (A and C):

1. In 1966, after 1 year

$$= \frac{(\text{Total no. nesting ♀♀ in 1966})(\text{Total no. ♀♀ in 1966 known alive and banded, after 1 year})}{\text{Total no. ♀♀ trapped in 1966}}$$

$$= \frac{(77)(21)}{40} = 40$$

2. In 1967, after 1 year

$$= \frac{(\text{Total no. nesting ♀♀ in 1967} - \text{Total no. ♀♀ in 1967 known alive and banded, after 2 years})(\text{Total no. ♀♀ in 1967 known alive and banded, after 1 year})}{\text{Total no. ♀♀ trapped in 1967} - \text{Total no. ♀♀ known alive and banded, after 2 years}}$$

$$= \frac{(64-8)(3)}{37-8} = 6$$

3. In 1967, after 2 years

$$= \frac{(\text{Total no. nesting ♀♀ in 1967} - \text{Total no. ♀♀ in 1967 known alive and banded, after 1 year})(\text{Total no. ♀♀ in 1967 known alive and banded, after 2 years})}{\text{Total no. ♀♀ trapped in 1967} - \text{Total no. ♀♀ known alive and banded, after 1 year}}$$

$$= \frac{(64-6)(8)}{37-6} = 15$$

(continued)

Appendix 3 (continued)

B.) Survival rate between years "y" and "y+1 or 2" = $\dfrac{\text{Total no. banded ♀♀ on islands A and C in year "y+1 or 2"}}{\text{Total no. ♀♀ newly banded in year "y"}}$

C.) No. ♀♀ surviving in year "y+1 or 2" from those banded in year "y" = (Survival rate in year "y+1 or 2")(Total no. ♀♀ newly banded in year "y")

APPENDIX 4

Formula used to calculate expected values in Tables 21 and 22.

$$\text{No. nests expected in year "y" category "x"} = \frac{(\text{Total no. nests observed in year "y"})(\text{No. nests observed in year "y-1" category "x"})}{\text{Total no. nests observed in year "y-1"}}$$